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THE RESOURCES, PRODUCTIONS AND SOCIAL CONDITION OF SPAIN.

By Alexander Delmar,

late director of the bureau of statistics of the united states, etc.

(*Read before the American Philosophical Society, January* 15, 1875.)

Introduction.

Until very lately there were few or no histories or works of reference in the English language relating to Spain which contained any information with regard to that country later than for the period 1855-61; and a survey of the condition of Spain from the stand-point thus afforded presented but a gloomy prospect. During the sixty-one years ending with the latest date to which these works bring the student, the population of Europe and America had nearly doubled, and this increase in the numbers of the foremost races of the world was, as it always is, merely the type of that vast and almost universal material progress which renders such increase possible.

During the same momentous period, serfdom and slavery had been condemned or abolished in both continents, and with it the feudal system and the corvée. During the same time mankind had armed itself with the titanic powers of steam and electricity, and rushed with renewed strength into that perpetual struggle with nature, which is its heritage, but in the maintenance of which, at about the beginning of the period referred to, it had become well-nigh exhausted, for lack of suitable weapons and appropriate agencies. This epoch, too, had witnessed in many countries the separation of Church and State, the obliteration of castes, the spread of popular education, the establishment of popular representation, the mobilization of proprietary rights, the development of great scientific progress, and a brilliant series of discoveries in every department of thought.

During all this time, marked by the mightest strides of material progress which the world had ever seen, that country of Europe which, while the rest of the Continent was shrouded in the darkness and bigotry and superstition of the Middle Ages, once held aloft the lamp of science and built up with the hands of its Semetic occupiers a civilization several centuries in advance of its time; that country from which subsequently went forth the imperial dicta that controlled one-half of the Continent, and all of the newly discovered world beyond the Western Ocean, lay inert and motionless.

The country of Abderrahman, of Alfonso el Sabio, of Ximenes, had made no sensible progress for centuries. The numbers of the people were substantially the same, the institutions were the same, the lives they led were the same. So late as the year 1855 but one-fifth of the surface of Spain was cultivated; the rest had been blasted by a ruinous system of exploita-

tion. A great portion of the entire country, cultivated and uncultivated, was owned by the Church and nobility. The Inquisition had been but recently suppressed; the peasantry were still in a condition of serfdom, the corvée was in vogue, the country swarmed with drones, bandits, smugglers, vagabonds and beggars; religious liberty was denied, and popular education was almost wholly unknown. There was no scientific development; no well-established middle class, and but the beginnings of a newspaper press and a railway and telegraph system. There were few or no roads, or manufactories, while commerce was restricted, and free discussion prohibited. In a word, Spain, though she had made more than one abortive attempt to do so, had not yet fully awakened from the torpid condition into which she had been cast ages before by the cold hands of ambitious, unpatriotic and selfish ecclesiastics. The rest of the world had long since awakened to a life of freedom and joined in the race of modern development; Spain was still asleep, drugged with the fumes of prescribed ignorance and dictated intolerance.

It is not held that this was truly the condition of Spain so late as up to 1855-61; but that this is substantially the picture of it that is to be found in many of the most authoritative and latest works of reference now extant in our language on the subject.

The following view of Spain was written during the reign of Ferdinand VII—about forty or fifty years ago (Macgregor, 994):

"Exclusive of about a fourth of the population, composed of persons living on their property without doing anything, Spain, according to the census of 1797, contained 100,000 individuals existing as smugglers, robbers, pirates and assassins, escaped from prisons or garrisons; about 40,000 officers appointed to capture these, and having an understanding with them; nearly 300,000 servants, of whom more than 100,000 were unemployed, and left to their shifts; 60,000 students, most of whom begged or rather extorted charity at night, on the pretence of buying books, and if to this melancholy list we add 100,000 beggars, fed by 60,000 monks at the doors of their convents, we shall find that at the period referred to, there existed in Spain nearly 600,000 who were of no use whatever in agricultural or the mechanical arts, and who were only calculated to prove dangerous to society. Lastly, having made these and other necessary deductions, we find that there remained 964,571 day laborers, 917,197 peasants, 310,739 artizans and manufacturers, and 34,399 merchants, to sustain by their productive exertions 11,000,000 of inhabitants. These results which, *mutatis mutnndis*, are applicable at the present day as at the time when they were deducted, exhibit a state of society so radically corrupt and debased as to render all hopes of its regeneration very nearly desperate."

Said M'Culloch, writing in 1844: "Owing to vicious institutions, bad government and other causes, Spain has, for a lengthened period, continued stationary or made little progress, while other nations have advanced with giant steps in the career of improvement."

Said Macgregor, in 1850: "The government of Spain can scarcely be considered less despotic than Russia or Turkey;" and he goes on to speak of "the backward state of agriculture in Spain, the indolence of the rural population, the great numbers who are otherwise employed than in husbandry, and the preference given to pastoral occupation over that of tillage," etc.*

Appleton's Cyclopedia, which is dated 1864, though it notices the beginnings of a recently developed appearance of progress in Spain, states that agriculture there is still in its infancy, notices the continuance of the *Mesta* and other institutions of the Middle Ages, and chronicles the then recent conservative reaction typified by the restoration to the Church of all the lands that had not been sold.†

In brief, the picture of Spain, which is obtained from the usual works of reference on the subject, depended upon, or accessible to, the American student, is that of a Spain still sleeping the sleep of the centuries.

But this picture is incorrect. Since the date of these works, or of the information which they contain, Spain has made, what is for her, enormous progress. From absolutism to constitutionalism was for her but a single jump, and not like France in 1789 through a Reign of Terror, but by the progressive steps of an orderly and deliberate revolution. This

* The following tables, though obviously imperfect, may nevertheless afford an indication of the backward social condition of Spain previous to recent changes:

DRONES IN SPAIN.

CLASSES OF DRONES.	Year 1797. Macgregor, p. 994, and M'Culloch, 840.	Year 1826. Macgregor, p. 944, and M'Culloch, 840.	Year 1857. Martin, etc.
Smugglers, etc.	100,000	100,000	.....
Custom Officers	40,000	40,000	27,922
Domestic Servants	300,000	276,000	206,090
Student Beggars	60,000	.....	47,312
Beggars	100,000	36,000	.....
Monks	61,617	61,727	125,000
Nuns	32,500	24,007	
Other Ecclesiastical	81,803	85,735	
Vagabonds	.....	140,000	.....
Inquisitors	2,705	22,000	.....
Officers of Inquisition	.....		
Wandering Convicts	.....	2,000	.....
Army and Navy	500,000	100,000	241,335
Nobility	350,000	.....	478,716

The classification involves questions of opinion and taste in which I am far from agreeing with the writers from whom I quote.

The following table, from various authorities, shows the ecclesiastical population of Spain at various dates:

Year.	Number.	Year.	Number.
1787	188,625	1857	125,000
1803	203,298	1862	39,885
1833	175,574	1870	.....

Without feeling at all certain of the accuracy of these numbers, I think it safe to conclude that since 1855 the porportion of ecclesiastics in Spain has very materially decreased.

† These lands were again taken from the Church and sold, the Church receiving an equivalent for them in money. During the subsequent civil war this payment was stopped. Upon the recent accession of Alfonso XII, it was resumed. The substantial point of the whole history is that the people have got the lands and no reaction can deprive them of them.

revolution, like its predecessor in the same country of half a century before, may have gone too far and subjected itself to the evils of a conservative reaction which in time will destroy all its good effects, but this is not believed to be the case. During the late years preceding and during its republican government, the Spanish nation so thoroughly destroyed the power of the bigots, so utterly abolished feudal institutions, so scattered to the winds the privileges of castes and monopolies and so clinched and riveted these reforms by the educational institutions and agencies of material progress which it created, that for it to go back to the dark ages of twenty years ago is simply impossible. Several millions of people in Spain have learned to read during the past fifteen or twenty years; several thousand miles of railways have been built; several millions of acres of additional land brought under cultivation. These are works of progress that cannot be undone. Spain is like an inert mass suddenly hurled into the illimitable space of action; she must go on now forever.*

In endeavoring to portray the recent progress of Spain, I shall confine myself in this paper chiefly, though not entirely, to the important topic of agriculture, and the sub-topics more immediately connected with that greatest of all industries. This is done not only because progress in Spain means, and must, for some ages yet, mean, necessarily and above all things, progress in agriculture; but also because it is upon this subject that current works of reference on Spain are most deficient.

Natural Resources, Climate, etc.

Of this once most foremost country of the world, it may be said briefly that nature gave her every original resource and man destroyed them all. Situate in the temperate and tropical zones, watered by two oceans, and penetrated by no less than 230 rivers, nearly one-half of her soil still lies barren, for the want of moisture denied her by the destruction of her forests. The average fall of rain during the year is stated to be "19.45 inches, while the average heat is 65° 42′ Fahrenheit, even in winter only falling to 56° 54′ and in summer ascending to 99°." U. S. Com. Rel., 1868, p. 373.

In Alicante and many other provinces it seldom rains at all. When it does, the floods are often very destructive. In November, 1864, an extraordinary inundation took place in the province of Valencia, causing the river Ircar to overflow its banks, partially destroying the town of Alcira, and inflicting damage to the amount of over two million dollars (Br. C. R. 1865, p. 73). Spain is essentially a country of mountain ridges and ele-

* "Don José Sanchez de Bazan gave me some highly interesting accounts of recent Spanish progress, and the state of affairs in his country. There were three thousand miles of railways in Spain; over twelve million passengers were annually carried upon them; there were seven thousand miles of telegraph, fifteen thousand miles of common roads, etc. The Constitution guaranteed complete civil and religious liberty; the priests were banished; the press was free, and Spain would soon once more lift up her head among the nations."—*A Summer Tour in* 1872, by Alex. Delmar. Appleton's Journal: New York, November, 1873.

vated plateaux, the former being filled with mineral riches, the latter once the scene of immense agricultural productions.

Moneys, Weights and Measures.

Previous to July 19, 1849, the weights and measures of Spain differed in every province*, though those of New Castile, the province in which the capital of the country is situated, were the ones generally employed in works relating to the entire country. The following table shows the principal moneys and principal weights and measures in use previous to the establishment of the metrical system :

Moneys, Weights and Measures—Old System.

1 Escudo,	equal to (exchange value, about)	$0.50	U. S. Gold.
1 Real de Plata,	"	.10	" "
1 Real de Vellon,	"	.05	" "
1 Arroba of wine,	"	4.268 gallons.	†
1 Arroba of oil,	"	3.323 "	†
1 Aranzada,	"	1.105 acres.	‡
1 Fanegada,	"	1 591 "	‡
1 Fanega,	"	1.55 bush.	‡
1 Libra,	"	1.0144 lbs. avoir.	§

There is also a land measure used in Valencia, and perhaps elsewhere, called the *hanegada*, equal to 0.2062 acres. The *cahiz* is equal to 12 *fanegas*, or 18.6 bushels.

Moneys, Weights and Measures—New System.

Although the metrical system was established throughout the entire kingdom of Spain by the law of July 19, 1849, the old metrology continued to be employed in Spanish works so late as 1859, and sometimes it is still used. Under the present system Spanish names are given to the French moneys, weights and measures. The franc is called the *peseta;* the metre, *metro;* the litre, *litro*, etc. The equivalents of these terms are well known.

The reform effected by the adoption of the metrical system in Spain, though insignificant when compared with the far more essential reforms which will presently be alluded to, is nevertheless not altogether unim-

* For a full account of Spanish provincial metrology see book of Instructions to Spanish Consuls, a work to be found in the hands of the various Spanish consular officials throughout the world.

† Von Baumhauer.

‡ The best authorities for these equivalents are : 1. The Official Instructions to Spanish Consuls; and 2. The able paper of M. Von Baumhauer, published in the Report of the Seventh International Statistical Congress, vol. 3, p. 173. These authorities agree substantially as to the Castilian *Aranzada* and *Fanegada*. The Spanish work establishes the *Aranzada* at 4471.92644 metres; M. Von Baumhauer says 44.71918 ares. The Spanish work fixes the *Fanegada* at 6439.574075 metres; M. Von Baumhauer says 64.39533 ares. But when it comes to the *Fanega* they differ. The Spanish work sets it down at 55.101055 litres; while M. Von Baumhauer says 55.50123 litres. Other authorities differ from both of these. Deeming the Spanish official publication the highest authority on the subject, I have adopted the equivalents therein established as being the most correct. The American equivalents of the metrical weights and measures are from the invaluable little work of Dr. B. F. Craig, of Washington, D. C., which corrects the errors of the British Assay Office.

§ Von Baumhauer.

portant; for it rendered possible intercommunication and commercial dealings between the various provinces of Spain which, under the old system, were almost impossible. There were *arrobas* and *fanegas* and *fanegadas* in all the provinces, but no two were of like value, and they differed enormously. The *fanegada*, which contained 576 *estadales carrés* in Castile, contained from 100 to 625 in the other provinces, and the *aranzada*, which contained 400 in Castile, contained from 300 to 600 elsewhere. (Von Baumhauer.) With an illiterate population, such a diversity of terms was tantamount to an almost entire prohibition of intercourse between the provinces.

Total Area of Country.

In the Spanish statistical tables, Spain is usually meant to embrace the Balearic and Canary Isles. The following table gives the total superfices:

	KILOMETRES CARRÉS.	MILES.	ACRES.
Spain proper	494,946	190,257	121,764,480
Balearic Isles	4,817	1,852	1,185,280
Canary Isles	7,273	2,796	1,789,440
Total	507,036	194,905	124 739,200

Cultivated Area at Various Dates.

I have before me nine different accounts of the cultivated area of Spain at four different periods, viz.: 1. The account of Miguel Ozorio y Redin, who wrote in the last half of the seventeenth century; 2. The official returns for the year 1803; 3. An account from the *Junta de Medios*, concerning the divisions of land in 1803; 4. A statement laid before the Cortes in 1808; and 5, 6, 7, 8, and 9, various accounts relative to the divisions of land from the year 1857 to the present time. Of these accounts the earlier ones have generally been treated by English writers as more or less fanciful; on the contrary, I believe them, when rightly understood, to be more or less correct. Confusion of the terms, "productive land," "cultivable land," "cultivated land," "arable land," "area sown in grain," and "area in which grain is sown," as well as error in the translation of "fanegadas" and "fanegas" being sufficient to account for their apparent discrepancies.

Selecting the second one, as perhaps the most reliable, we have the following divisions of Spain proper for the year 1803:

DIVISIONS OF LANDS 1803.	SQUARE LEAGUES.	ACRES.
Cultivated lands and fallows	4,310	27,627,100
Pastures and commons	11,658	74,727,780
Forests and copses	1,580	10,127,800
Mountains and rivers	1,342	8,602,220
Total	18,890	121,084,900

I deem the following to be the most reliable one relative to any late year preceding the period of recent progress:

DIVISIONS OF LAND IN 1857.	ACRES.
Land sown in grain, potatoes, beans and peas, roots, vegetables, commercial crops, fallow land, grass land under rotation, chestnut groves, orchards and gardens	32,210,071
Vineyards	2,906,783
Olive grounds	2,122,780
Meadows and pastures	16,926,028
Mountainous lands	10,832,730
Sites, mines and quarries	3,586,247
Total productive land	68,584,589
Forests	6,885,600
Barren and waste; also lakes, rivers, roads, etc.	49,269,011
Grand total	124,739,200

Comparing the two accounts, so far as their different classifications will enable a comparison to be made, we have the following results:

DIVISION OF LAND.	1803. SPAIN PROPER. ACRES.	1857. SPAIN AND THE ISLES. ACRES.	GAIN OR LOSS. ACRES.
Cultivated and fallow	27,627,100	37,239,584	G. 9,612,484
Forests	10,127,800	6,885,600	Loss.
Copses			Loss.
Mountains	8,602,220	10,832,830	Unchanged
Rivers		Inc. in "Barren."	Unchanged
Sites, etc		3,586,247	
Meadows and pastures.	74,727,780	16,926,028	Unchanged.
Barren, waste, etc.		49,269,011	Loss.
Total	121,084,900	124,739,200	

Beyond the essential point that nearly ten million of acres were added to the cultivated lands, it can only be stated roughly that the forest lands of Spain, which, so far as concerns the period under review, were never extensive, slightly diminished; the pasture lands (properly speaking, there were few or no meadows in Spain), remained unchanged, and the common and waste lands diminished, by being brought partly under cultivation.

IRRIGATION.

Of the above mentioned 37,239,584 acres of cultivated land, 2,857,648 acres were irrigated as follows:

DIVISIONS OF IRRIGATED LAND.	FANEGADAS, EACH OF 1.60 ACRES.	ACRES.
Arable land	1,370,090	2,192,144
Vineyards	67,374	107,755
Olive grounds	74,618	119,389
Other	273,970	438,360
Total	1,786,025	2,857,648

Land Sown in Grain and Potatoes.

Of the 32,210,071 acres of land devoted to grain and other products, or in fallow, the following portions were sown in grain and potatoes only:

Wheat	7,311,892	acres.
Barley	3,182,100	"
Rye	2,961,863	"
Maize and other grain	1,351,687	"
Potatoes	509,503	"
Total	15,316,865	"

The divisions of land in 1874 are estimated as follows:

Divisions of Land in 1874.	Acres.
Cultivated and fallow:	
Arable land, *i.e.*, land sown in various crops, fallow land, grass under rotation, groves, orchards and gardens	40,000,000
Vineyards	3,000,000
Olive grounds	2,000,000
Meadows and pastures	17,000,000
Mountainous land	10,800,000
Sites, mines and quarries	3,700,000
Forests	6,800,000
Barren, waste, public and water surfaces	41,439,200
Total	124,739,200

The cultivated and fallow lands, which amounted to less than 28,000,000 acres in 1803, and about 37,000,000 acres in 1857, now amount to 45,000,000 acres; showing as great progress during the seventeen years from 1857 to 1874 as occurred in the fifty-four years from 1803 to 1857. According to this measure, progress has been thrice as rapid during recent years as it was previously.

Population.

According to Martin, Spain, in the time of Julius Cæsar, contained a population of 78,000,000; according to a Spanish author quoted in the U. S. Com. Rel., 1865, p. 169, she had 68,000,000; according to Appleton's Cyclopedia she had 40,000,000. I place no reliance whatever on these conjectures. Seaman's Progress of Nations, p. 551, also contains a series of conjectures on the subject which are certainly wrong or fallacious. The earliest authentic account of the population of Spain, dates about five centuries ago, when under the Moors, she was stated to have contained 21,700,000 inhabitants. This account—from the number and opulence of her towns, the works of improvement executed and which still remain, the breadth of land cultivated, the number of houses, workshops, artisans, etc., all of which are known with reference to many localities,—this account I believe to be substantially correct.

Through the expulsion of the Moors, who were the agriculturists, and the Jews, who were the manufacturers and merchants of Spain, this vast population, which, in my opinion, is the greatest the soil of Spain ever

supported, gradually dwindled down to about 7,600,000 inhabitants in 1723. From the last named period it has very slowly increased to somewhat over 17,000,000 at the present time.*

The following table exhibits the data on this interesting subject, together with such remarks as I have deemed were necessary to be made and the authorities from whom I have quoted. I have indicated the figures which I consider incongruous by placing them in brackets.

POPULATION OF SPAIN AT VARIOUS PERIODS.

(The figures in brackets do not appear to agree with the others.)

Year.	*Population*	*Authority.*	*Remarks.*
13th Cen.	21,000,000	Rep. Br. Sec. Leg., 1866	Quoted from Spanish author
1380	21,700,000	Castile 11,000,000, Arragon 7,000,000 and Grenada 3,000,000	
1594	8,206,791	Rep. Br. Sec. Leg., 1866	
1618	[9,000,000]	Cevallos	Quoted by Macgregor.
1618	7,500,000	Ustariez	Quoted by Macgregor.
1688	[8,000,000]	U. S. Com. Rel., 1865	
1700	[8,000,000]	Macgregor	At death of Charles II.
1723	7,625,000	"	From an official census.
1726	[5,423,000]	"	Excludes nobility and clergy
1768	9,307,800	Com. Rel., 1865	
1769	9,301,728	Macgregor	Includes Canaries and African settlements.
1770	9,307,000	"	
1788	10,143,000	"	Excludes Canary Isles.
1789	10,761,485	Com. Rel., 1865	Includes Canaries, etc.
1797	10,541,000	Appleton's Cyc	
1797	[12,000,000]	Com. Rel., 1865	
1803	10,351,000	Macgregor	Census, Spain proper.
1803	10,351,075	U. S. Census, 1850, p. xxxiv	Spain and Balearic Isles.
1820	11,000,000	Com. Rel., 1865	
1821	11,248,000	Macgregor	Census, Spain proper.
1821	11,248,026	U. S. Census, 1850	" " "
1823	12,000,000	Com. Rel., 1865	
1826	[13,712,000]	Macgregor	Cadastral ret'ns, Spain pro'r
1827	[13,953,957]	"	Cadastral ret'rn, Spain and Balearic.
1828	[13,698,000]	Com. Rel., 1865	Martin says 13,698,029.
1833	12,087,991	Ency. Amer., vol. 14	Official. Excludes Balearic.
1833	12,386,841	Alm. de Gotha, 1850	Official. Includes Balearic and Canary Isles.
1834	[14,660,000]	Macgregor	Estimated.
1834	12,232,194	U. S. Census, 1850	From Guibert.
1834	12,168,774	"	From M'Culloch.
1837	12,222,872	Martin	
1842	12,054,000	"	
1846	12,166,774	"	Includes isles.
1849	13,705,500	Alm. de Gotha	Spain proper.
1850	[10,942,280]	Br. Rep. Sec. Leg	Incorrect.
1857	14,957,575	Alm de Gotha	Spain proper.
1857	[15,807,753]	Martin	Spain proper. Details given.
1859	15,460,000		Estimate.
1860	15,673,481	Rep. 7th Inter. Stat. Cong., vol. 3.	The enumeration dates Dec. 31 in each year.
1861	15,867,304	" " " " "	
1862	16,043,703	" " " " "	
1863	16,180,183	" " " " "	
1864	[15,752,607]	Br. Stat For. Coun	Spain proper.
1864	16,302,148	Rep. 7th Inter. Stat. Cong, vol. 3.	The enumeration dates Dec. 31 in each year.
1865	16,378,481	" " " " "	
1866	16,526,474	" " " " "	
1867	16,656,879	" " " " "	
1868	16,732,052	M. S. 21-41-2-349	
1868	[16,090,550]	Br. Stat. For. Coun	Spain proper.
1869	16,800,000	Estimate	Spain proper.
1870	16,935,613	Br. Stat. For. Coun	Spain proper, census returns.
1871	17,000,000	Estimate	Spain proper.
1872	17,100,000	"	Spain proper.
1873	17,200,000	"	Spain proper.
1874	17,300,000	"	Spain proper.

* It is believed by some writers that the population of Spain again retrograded subse-

This is a most instructive table.

First. It shows an extraordinary decrement of the population of Spain from about the beginning of the fifteenth century until after the beginning of the eighteenth. This is attributed chiefly to the Moorish and Jewish exodus which commenced to take place in the year 1492, the same year in which that New World was discovered in which eventually so many of the exiles found both homes and religious liberty. From first to last it is supposed that no less than 300,000 Moorish and 300,000 Jewish* families, or nearly three millions of intelligent and industrious people were driven from Spain, and amidst the most shocking cruelties. These, together with the numbers who fled after the conquest of Grenada and the colonists to America, contributed to reduce the population from nearly 22,000,000 in the fourteenth century to little more than 7,000,000 in the seventeenth. Notwithstanding the persecution of the Moors and Jews, it is stated that considerable numbers remained in Spain, professing, if not believing, in the doctrines of the Church, and forming the bulk of the agricultural and industrial classes in many localities. This is affirmed by Macgregor and denied by Buckle, but I think the weight of evidence is with the former. M'Culloch, p. 845, says there were 60,000 Moriscoes in Grenada in his time, about the year 1840.

Evidence of the large population that dwelt in Spain under the Moorish régime is found in a class of facts, of which the following are examples:

"Before the Conquest in 1487 (the city of) Grenada had 70,000 houses and 400,000 inhabitants, 60,000 of whom were armed. It was defended by ramparts flanked by 1030 towers and two vast fortresses, each of which could receive in garrison 40,000 men.

"The kingdom (of Grenada) of which it is the capital, was only thirty leagues in breadth by seventy in length, but it contained thirty-two large cities and ninety-seven towns and 3,000,000 of inhabitants. The whole population at present does not exceed 83,000.

"The city of Cordova under the Moors occupied nearly eight leagues of the banks of the Guadalquiver, and contained 600 grand mosques, 3,837 small mosques or chapels, 4,320 minauts or towers, 900 public baths, 28 superbs, 80,455 shops, 213,070 dwelling-houses, 60,300 hotels or palaces." *Moreau de Jonnés*, 1834.

"The last official census states that 1,511 towns and villages were then totally uninhabited and abandoned." Macgregor, 1850.

For further evidence on this point, consult Buckle's *Hist. Civ.*, Draper's *Hist. Civ.* and *Civil Policy of America*.

Second. The table of population shows a very slow increment from the

quent to the year 1830. This opinion is probably based on the cadastral returns of 1826, or thereabouts, and the smaller numbers of the census returns of 1833. It may be well-founded; but I have ventured to disregard it in arranging the figures of the text.

* This is the highest estimate. Buckle, who quotes a number of authors, states that the number of Jews actually expelled is differently estimated at from 160,000 to 800,000. —*Hist. Civ.*, ii, 15.

beginning of the seventeenth century to about the year 1850. The population is stated to have been 7,500,000 in the year 1618 and 13,705,500 in 1849. This is an increase of but 82.7 per cent. in 231 years!

Third. The table shows a comparatively rapid increment of population since about the year 1850, to-wit: from 13,705,500 in 1849 to about 17,300,000 in 1874, an increase of 26.2 per cent. in 25 years. This is the period of recent progress in Spain to which attention has been directed, and it is believed no better proof can be adduced in support of this allegation of progress than the rapid increment of population which, in spite of foreign and civil wars, has taken place.

Rural and Civic Population.

The cadastral returns of 1826 gave the rural population at 80.4; the civic at 18.5, and the ecclesiastical at 1.1 per cent. of the whole. The proportion of rural population therein shown is probably correct at the present time.

Agricultural Population.

Spanish statistics, at least as they reach compilers outside of Spain, are proverbially incomplete, contradictory and obscure, and they are no less so on this simple subject than on any other which I have found it necessary to examine. The agricultural population of a country but half cultivated, and that portion but indifferently tilled—a country, which, as a rule, has forbidden the importation of breadstuffs, while it had none to export; which is neither a pastoral nor a new country; and in which the struggle for subsistence is so great that a local and temporary drought is enough to stimulate what is else a constant but sluggish stream of emigration to other countries—ought to be uncommonly large. On the contrary, my information states it to be comparatively small. If the latest figures before me are corrrct, the agricultural population of Spain is but 55 per cent. of the whole; whereas I am confident it is not less than 65 to 70 per cent. The following is the statement:

Occupations of the Population of Spain, 1857.

Non-Agricultural Male Adults.		Number.
Army, Navy and Military functionaries		241,335
Officials: State	22,362	
Municipal	62,976	
Provincial	4,693	
		90,031
Nobility		478,716
Clergy		125,000
Students	47,312	
Advocates	5,673	
Writers	9,351	
		62,336

Non-Agricultural Male Adults.	Number.
Servants	206,090
Merchants	119,234
Scientific	35,736
Artists and mechanics	88,728
Manufacturers	67,327
Miners, (1864)	32,201
Workmen in refining and smelting works, (1864)	9,945
Fishermen, 1866	39,440
Seamen in ports, harbors, etc., 1863	11,285
" foreign trade, 1863	16,181
" coasting trade, 1863	21,606
Total	1,645,191

Total able-bodied men, 3,803,991. This would leave, at the most, but 2,158,800 agriculturists. At an average of four inhabitants to each able-bodied man, this would imply, at the most, an agricultural population of 8,632,000, which is 55 per cent. of the whole. Add to the 2,158,800 male adult agriculturists about 340,000 female laborers, and we have in round numbers 2,500,009 persons actually employed in agriculture. This number forms less than 16 per cent. of the whole, a proportion that, taking into consideration the rude state of tillage in vogue, would seem entirely inadequate to produce the requisite amount of food for all.

Macgregor (p. 944) publishes the details of a cadastral return of the population for 1826, concerning the correctness of the total sum of which there is perhaps some doubt. The total figure is 13,712,000, while the total of the table of details is but 13,211,301. In this table the agricultural population is placed at 1,836,320 heads of families and others, and 6,777,140 women and children, the first-named figure being 13.9 per cent. of the whole and the latter 65.2 per cent. The details of heads of agricultural families and others are as follows: Proprietors, 364,514; farmers (middle men), 527,423; laborers, 805,235; proprietors of herds and flocks, 25,530; and shepherds, 113,628.

I am inclined to believe these proportions to be nearer the truth, and the truth at the present time, than those deduced above.

The discrepancies have doubtless arisen less from any material changes in the occupations of the people than from the fact that in many districts the agricultural laborer often alters his trade during the year; so that the agreement of two censuses would depend largely upon the time of the year they were taken respectively. (See on this point, L. T., 24, § 9.)

Female Laborers.

In Galicia and Asturias the number of female laborers is nearly equal to the male. These districts comprise about one-fifth of the population. In Carthagena, province of Murcia, population 380,969, female labor is seldom or never employed for field work. In Minorca female labor is employed hardly at all. In Majorca it is employed. Female laborers are

employed, but not generally, in Guipuzcoa, Basque Provinces, population 162,547. In Biscay, Basque Provinces, population 200,000, all the females work in the fields at times, and female labor is largely employed. In the Provinces of Malaga, Granada, Almeria, and Jaen, population 1,565,979, female labor is hardly at all employed in the cultivation of land, only in gathering olives and cutting grapes. From these and other reports (Land Tenures, Part III), I have ventured to estimate the number of female laborers in Spain at about 340,000, though I dare say the true number is upwards of 500,000.

Land Tenures.

The laws of 1820 abolished the right of primogeniture and all other species of civic entail (*mayorazgos*); then followed that of 1841 on ecclesiastical benefices, and finally that of 1855, which declared in a state of sale land and house property belonging to the State or appertaining to corporations of towns, beneficence, public instruction, clergy, religious fraternities, pious works, sanctuaries, etc. Like many other reforms which have taken place from time to time in Spain, certain provisions of this one were rescinded, and it was not until 1865 that the Crown lands were finally decreed in a state of sale. It is, however, from the year 1855 that the freedom of Spain from religious and feudal tenures really dates.

When it is considered that these tenures were abolished in France by the Revolution of 1789, in the United States, generally, during the earliest days of their history as independent Commonwealths, and in Prussia in 1820, it cannot be deemed strange that a country which did not succeed in throwing them off until 1855 should have failed to show any signs of progress until within very recent years.

The condition of affairs in 1840 is thus described:

"Mr. Townsend (ii, 238) mentions that the estates of three great lords —the Dukes of Osuna, Alba, and Medina Cœli—cover nearly the whole of the immense Province of Andalusia; and several in the other provinces are hardly less extensive." M'Culloch, p. 837.

"The great estates belonging to the corporations, or towns, are held in common; and in consequence are wholly, or almost wholly, in pasture." —*Ibid.*

In 1850, we have the following account:

"Among the causes of the defective state of agriculture in Spain are the tenures of land. The unalienable, indivisible *mayorazgos* (entails) are considered as having for a long period comprised, including the property of the Church, about *three-fourths* of the territorial surface of Spain.

"The *Mesta* is another great, although secondary, cause of the neglect of agriculture. This is the name of a great incorporated company of nobles, ecclesiastical chapters, persons in power and members of monasteries, who were authorized to feed their flocks, at scarcely any expense, on all the pastures of the kingdom, and have almost an imperative special code of laws (*Leyes y Ordenenzas de la Mesta*) for maintaining their originally usurped privileges. It holds its courts and has numerous Alcaldes,

Entregadors, Quadrilliers, Achagueros, and other law officers. Within the last five years, the *Mesta* has possessed about half of the sheep in Spain." Macgregor, p. 1016.

For lists of the religious establishments and the enormous properties and revenues they absorbed, see pp. 1023–5 of the same work.

As to the condition of affairs at the present time, the bulk of agricultural lands in Spain appear to be still held by wealthy or noble proprietors, who live in the cities and lease them out on half produce, *a la meta*, to indigent peasants. Feudal tenures are indeed swept away, but many of the features of feudality remain, and it is still the custom in Alicante and perhaps elsewhere, for the metayers to present the proprietors with a certain number of fowls each year. The custom is now voluntary and by no means relished by the owner, who feels bound to make some return; but it serves to indicate the relations between the metayer and his landlord. The metayers on rice plantations in Valencia pay one-third produce. Certain rights of commonage appear to continue. (L. T., 40, § 7.) In Galicia, the "foro" is mentioned so late as September 30, 1870. (Com. Rel., 1871, p. 1008.) The "foro" is a sort of land impost created some eight or nine centuries ago, and continues to be paid annually by the present owners to the descendants of the former proprietors of land. "The importance of this tribute is such that it sometimes absorbs the total productions of the soil; thus it is that two-thirds of it has never been cultivated." (*Ibid.*?) In October, 1873 (Com. Rel., 1873, p. 946), it is stated that the feudal tribute of "foro" had been declared redeemable by the Government.

In fine, Spain may be said to have scarcely even yet emerged from the feudal state. A large portion of her soil is still owned by absentee landlords and rented, partly for money rents and partly *a la meta*. The proprietors seldom sell their properties (L. T., 42, § 10), and there is no compulsion on their part to sell, lease, or otherwise dispose of their property to peasants or others. (L. T., 49, §§ 6–7–8.) But as the law of descent and division is the same that applies to personal property (*Ibid*, 43, § 2), it is merely a question of time when they will be divided and absorbed by peasant proprietors.

Another drawback is the allodial duty of two per cent. on the sale of lands. (L. T., 31.) There is a government duty of three per cent. on all transfers of property (p. 47, § 13). Whether the allodial duty of two per cent. is added to this, does not seem clear.

But the great fact remains that the feudal system and all entails are abolished; the lands of the religious establishments and the Crown* are sold, the corvée and the mesta swept out of existence, small peasant properties exist in large numbers all over the country, and the door is opened to further reform and future progress.

* In 1866 laws were also passed to facilitate the sale of mountainous lands.

Laws of Succession.

Land may now be willed as the owner chooses provided he has no children. In case he has, these are his natural heirs, and the division is in equal parts. He can, however, dispose of one-fifth thereof in favor of his widow, or some particular child, or even of a stranger. Should the property have increased in value since the marriage day of the owner, his widow has a right to the half of the increase (L. T., 19). While this is stated to be the law of Spain, the same authority speaks of the existence (Dec. 7, 1870) of separate codes of law affecting real estate in different provinces. (See pp. 40 and 43.) But this I doubt. The law of descent seems now to be general throughout the land, and to have been based on Novela cxviii of the Roman laws of Justinian.

Mortmain.

The abolition of mortmain (law of *desamortizacion*) took place in 1855, but many persons refused to buy church property on account of religious scruples. In 1858 the Pope's sanction was obtained, when the sales were actively continued, the Government giving great facilities to the purchasers. The payments are made one-tenth in cash and the remainder in promissory notes running from one to ten, and in some cases, nineteen years, and secured by mortgage on the property. Owing to these facilities of purchase the biddings have often more than twice exceeded the true market value of the parcels put up. The churches, etc., receive compensation for their lands thus sold, and the nation gains by the operation, what benefit accrues from throwing open lands to peasant ownership and industrious tillage, which had been either entirely sequestered or negligently worked by metayer tenants subject to the church. About $100,000,000 have been paid (in Government stock) to these institutions for their lands, and about $200,000,000 (in cash and mortgages) received from the purchasers. The total payments (for the operation has not yet quite ceased) are estimated at $125,000,000, and total revenues at $250,000,000; so that the Government will have made $125,000,000 by the law of mortmain. The interest on the payments to the religious establishments, which were made in Government securities, was stopped during the Republic, but an order for its resumption was among the first acts of Alfonso XII upon his accession to the throne of Spain in January, 1875.

Registry System.

"The sale or transfer of property (land) of every sort is always (now) done by deeds drawn up by a notary and inscribed in the Land Register. Leases of smaller importance are made by contract before witnesses. A tax of two per cent. is paid to the State in cases where property is held (hired?) or transferred; but where a son inherits directly from his father, or *vice versa*, no succession duty is paid. It exists, however, when the inheritance is from any more distant relative and increases proportionately." *Report of Percy Ffrench, First Sec. H. B. M. Legation in Spain.* L. T., 18.

Property is still administered and managed in Spain with great disorder and negligence, and extreme irregularity exists in the registration of leases, etc. This is probably due to the heavy registration, succession and other fees, and attempts to avoid them by neglecting proper formalities. Stamped paper must be used; only a feed notary can draw the papers, and fees attend every step of registration, search or certification. The average cost of transfer is about one and a-half per cent. *ad valorem.* (L. T., p. 44). In other respects the registry system, which has only been in force since 1863, appears to be similar to that which has always existed in the United States.

Hypothecation of Real Estate.

The very recent abolition of feudal and ecclesiastical tenures, the continued monopolization of the land by the wealthy (L. T., p. —), the newness, the exactions and disorder of the registry system, together with other causes, combine to render difficult the hypothecation of real estate. In cases where these obstacles do not exist, where the title is undoubted and the land held in fee, there is no difficulty in obtaining loans to the extent of one-third to two-thirds the value of the property, at six to ten per cent. per annum. But in most cases it is the landless metayer who desires to borrow and has nothing to offer as security but his growing crops. Upon such a precarious basis, ten to fifteen per cent. is a low rate to charge for interest, and often from thirty to forty per cent. is paid. (L. T., 18). With the means thus obtained numerous small holdings of mountain land (common land sold by Government under act of 1866) have been purchased by the peasantry on seven year annual installments (p. 30). This points to an extension of the same sort of spade culture which is to be seen in the hilly parts of Italy, and to the abandonment of the better but metayer-held lands of the nobility—a tendency that should not exist.

Positos.

"*Positos*" are described by Macgregor as a sort of co-operative society to supply seed corn and food in calamitous years, numbers of which have existed all over Spain since the time of Philip II. M'Culloch, however, defines them to be merely public granaries where corn may be warehoused until it is disposed of. The name, which means "depositories," proves this definition to be the correct one. They have diminished in importance of late years, probably because the fears of occasional scarcity, which, no doubt gave rise to them, have been removed by the construction of roads and railways and a more liberal policy in respect of the corn laws. The peasants and dealers in grain in Castile formerly preserved their stocks in *silos*, or subterranean caves, for sometimes five or six years.

Mesta.

As has already been explained, *Mesta* was a right of common which certain privileged classes possessed, but which is now abolished. It is

said to have originated in the fourteenth century during a famine. This right enabled the privileged owners of large flocks of sheep to drive them over village pastures and commons there to feed at pleasure, and to compel the owners of cultivated lands, which lay in the line of their migrations, to leave wide paths for the pasturage of the flocks. Nor could any new enclosures be made in the line of their march, or land that had once been in pasture be cultivated again until it had been offered to the *Mesta*, or corporation of flock-proprietors, at a certain rate! It is easy to perceive that with the continuance of such monstrous privileges as these it would only be a question of time when all the cultivated lands would be turned into pastures, and all the pastures fall into the possession of the *Mesta*. It was a great reproach to Spain that this feudal privilege existed so long as it did, but its recent abolition is equally an undoubted sign of progress.

Number and Size of Farms.

The number of farms in Spain in the year 1800 was but 677,520 in the hands of 273,760 proprietors and 403,760 tenant farmers. (Martin.) The number of landed properties, rural and urban, in 1857, was 2,433,301 (L. T., 46), and the number in 1870 was 3,612,000. (*Ibid*, 19.) The proportion of rural properties in late years is not stated by these authorities, nor are the tenures by which they are held set forth. The number of tenant farmers had increased from 403,760 in 1800 to 595,635 in 1857, and probably upwards of 600,000 in 1870; but meanwhile and particularly since 1855 the number of properties had increased, both by the subdivision of land and the industrial absorption of mortmain and Government lands and village commons. The bulk of the peasant farms will average between ten and fifteen acres. There are many vineyards of not over one-eighth of an acre, and on the other hand, many large properties, cultivated and uncultivated. The opinion appears to prevail among late observers that from one-fourth to one-third of the cultivated land is held by peasant proprietors (L. T., 50 and ?), and that the rest is cultivated by agricultural laborers, of whom there were 2,354,110 in 1857, in the employ of large owners, or farmed out to tenants for a money rent, or *a la meta*.

System of Culture—Seeding and Fertilizers.

Compared with other countries west of Russia and the Orient, the system of culture in Spain is still very backward. There are a few garden spots in Spain—the *huertas* of Granada, Murcia, and Valencia—but such exceptional instances of careful culture are to be found in the worst cultivated countries, even miserable Egypt possessing a Faioum. The general aspect of Spanish agriculture, until very lately, was much the same as it was a century ago when Arthur Young visited Spain. The great and numerous barrens he described are being brought under cultivation, and in that respect Spain is much improved; but the mode of cultivation is only now undergoing change. The forests were, centuries ago, burned for the few fertilizing materials to be obtained from their ashes, while

their annual efforts to increase were kept down by a similar treatment of their undergrowth and copses. Hence, barrens, afflicted with alternate droughts and floods. The system of agricultural irrigation was mainly a legacy from the exiled Moors, since whose time it had been but little enlarged. The means used for raising the water are the familiar *sakye* and *shadouf* of the Orient, the *sakye* being known under the name of *noria*. (L. T., 57.) The water obtained by these laborious means is known as *agua de arte;* that by diverting the course of streams as *agua viva*, or running water. (C. R., 1868, p. 373.)

As going still further to show the indebtedness of even Modern Spain to Moorish industry, it has been stated that the best olive trees in Spain to-day are those left by the Moors; while even the stone fences and other enclosures left by them are still performing the service for which they were constructed a thousand years ago.

Rotation was, until recently, very little followed in Spain, and even the fallow system, though in general use, was in many parts ignored and the ruinous one of exploitation, by a constant succession of the same sort of crops, employed in its place. (C. R., 1871, p. 1037.) Even two and sometimes three different crops were obtained from the same piece of ground in one year; though as Young and other writers have shown, with no aggregate increase of product, but on the contrary, diminution. Corn, root, or pulse crops were frequently sown in olive groves and vineyards to the mutual detriment of both tree or vine and crop. In the Provinces of Malaga, Granada, Almeria and Jaen, mention is made of a three-field system of, 1. Wheat, barley or beans; 2. Fallow; 3. Pasture on the unirrigated lands; and also of the continuance, so late as November, 1869, of village commons (*dehesas de proprios*) for cattle,—both of them wretched and antiquated features of agriculture. But since 1855 all these features have been undergoing change, and the *dehesas de proprios* were probably in a moribund state in 1869.

The quantity of seed used is uncertain. It is stated by M'Culloch that the *fanega* (about 1½ bushels) is the measure of seed-corn commonly sown upon a *fanegada* (about 1½ acres) of land, and hence, the similarity of terms. This is probably a true explanation with regard to the terms, which must, however, have arisen from the results of favorable sowings; for the practical fact is still that not less than two bushels are generally sown to the acre of wheat, the staple corn of Spain.

In the use of fertilizers the same recent improvement is to be observed as in other respects. Previous to 1855, beyond the fertilizers mentioned by Arthur Young nearly three-fourths of a century before, there does not appear to have been any improvement. These consisted of wood-ashes obtained from the burning, not of forests, for they had been burned long before, but of copses and undergrowth. Near some of the large cities poudrette seems to have been prepared, but the use of this fertilizer was not common.

Since the ameliorations, which date about the year 1855, Peruvian

guano appears to have been largely imported into Spain. I have the statistics by quantities for only the years 1852 to 1856 and 1863 to 1867, inclusive; but these will serve to show the extent of the movement, which first began in 1852:

IMPORTS OF PERUVIAN GUANO INTO SPAIN.

YEARS.	KILOGRAMS.	TONS.
1852 to 1856, inclusive	49,115,446	48,247*
1863	39,514,969	39,209
1864	6,437,943	6,324
1865	11,956,769	11,746
1866	46,872,576	46,043
1867	37,666,000	37,000

To show the relation which these quantities bear to the world's consumption of guano, it may be stated that the 48,000 tons imported in 1852 to 1856 formed but 2½ per cent. of the world's consumption of Peruvian guano; while the average annual quantity of 28,000 tons imported during the years 1863 to 1867 formed 7½ per cent. of the world's consumption, which was 370,000 tons per annum during that interval. (For details of the consumption of each country, see Com. Rel., 1867, p. 361.)†

The extent to which fertilizers are now being used in at least some parts of Spain, may be judged from the fact that the U. S. Consul at Valencia reported in 1871 that the ground in that district was being burned up by an immoderate use of guano!

AGRICULTURAL IMPLEMENTS.

There seems to have been no improvement in respect of agricultural implements since the days of Arthur Young. The corvée is abolished and the absentee landlords of vast estates, of whom he has so bitterly complained, are things of the past; but the old Roman plow, with its wooden mould-board, without a bit of iron upon it (Arthur Young, ii, p. —), and its four or five inch blade (Com. Rel., 1871, p. 1037,) remain. Indeed, even the plow is rarely met with in some provinces (C. R., 1866. 219), the "laya," or two-pronged fork, and the spade being used in its place (L. T., 37 and 51).

Until within a very few years, agricultural machinery was wholly unknown in Spain. The corn was left in the fields for lack of barns (Young); it was threshed by driving mules over it; it was winnowed by throwing it in the air (M'Culloch); and most frequently it was ground by hand rather than by wind-mills or other machinery. (*Ibid.*)

* Quantities *exported* from Chincha Islands *to* Spain, 1852-57.—App. Cyc., viii, 529.

† The average annual consumption by the United States before the war is set down by this authority at 40,000 tons; while the actual imports into the United States from 1850 to 1861, inclusive, were 954,989 tons, an annual average of double the quantity. However, a portion of this guano came from other places beside Peru. For complete statistics on this subject, see U. S. Com and Nav., 1867, p. xlvi.

Fanning machines are now in use near the towns; the thresher has been introduced; and the first American mower and reaper was imported a year or two ago.

English implements are too heavy for Spanish hands (L. T., 29), and many that have been imported are left to rot for want of men able to handle them. The American implements are much preferred.

On the whole, it may be stated that Spain is but on the threshold of a change from the inefficient implements of antiquity to the powerful machines of modern agricultural progress.

Domestic Animals.

Since the destruction of her forests Spain must have lost much of the pastoral character which undoubtedly distinguished her to a great degree under the rule of the Moors. There are now, properly speaking, no meadows (grass lands) in Spain. Young noticed a single patch during his journey in 1787; but late observers do not speak of any at all. (L. T., 28, and elsewhere.)

Said M'Culloch, about forty years ago:

"The Pyrenees, the hilly parts of Biscay and the Asturias, the vast plains of Andalusia, the two Castiles, Estramadura and Leon, are almost wholly in pasture; and in some parts the traveler may journey for many miles without seeing either a house or an individual. In point of fact, however, half the pastures really consist of heaths, or of neglected tracts covered with thyme and other wild herbs, that are at present next to worthless. There are few or no irrigated meadows, and hay is seldom or never prepared for fodder."

Except that portions of this waste land have of late years been reclaimed, this description will answer for to-day.

The following table exhibits a comparison of the number of domestic animals in Spain in 1808 and 1865, respectively, from which it will be seen that there has been a small increase of horses, a considerable increase of mules and asses, a decrease of horned cattle, sheep and goats, and an increase of swine.

It should be stated that a great many incomplete and incorrect statements on this subject have appeared in statistical works.

The authorities for the figures given in the text are, for 1808, the report to the Cortes quoted by Macgregor, and for 1865 the report of Senores Feliciano Herreros de Téjada and Victoriano Ballaguer to the Statistical Congress of the Hague.

Domestic Animals.	Year 1808.	Year 1865.
Horses	533,926	680,373
Mules and asses	1,079,002	2,319,846
Horned cattle	3,694,156	2,967,303
Sheep and lambs	24,916,212	22,468,969
Pigs	3,628,283	4,351,736
Goats	6,916,890	4,531,228
Camels	No data.	3,104
Poultry	"	No data.

In some parts of Spain there are no inclosures (fences), and cattle cannot be kept without injury to the crops (L. T., 28). Of late years a new and considerable trade has sprung up between Spain and England, consisting of exports of horned cattle and of eggs from the former to the latter. The following table shows the development of this trade since 1860:

QUANTITIES OF ANIMAL PRODUCTS IMPORTED FROM SPAIN PROPER INTO THE UNITED KINGDOM ANNUALLY SINCE 1860.

Calendar Year.	*Horned Cattle. Number.*	*Eggs. Great Hund'ds*	*Calendar Year.*	*Horned Cattle. Number.*	*Eggs. Great Hund'ds*
1860.....	3,573	.....	1867.....	13,816	93.064
1861.....	8,596	123,842	1868.....	15,985	116,895
1862.....	6,787	139,628	1869.....	19,589	96,131
1863.....	6,566	78,818	1870.....	27,271	112,638
1864.....	8,281	54,465	1871.....	19,612	184,114
1865.....	8,209	31,328	1872.....	15,462	151,296
1866.....	8,490	80.055	1873.....	19.888	151,564

CHIEF ARTICLES OF NATIONAL DIET.

The Spanish peasantry is even to-day but wretchedly fed; what it starved upon in the long and terrible ages of Ecclesiastical domination and feudal tyranny, defies all sober description. (On the general subject of peasant wretchedness in the Middle Ages, see *The Earth as Modified by Man*, by Marsh; New York, 1874, pp. 5–7, *the foot notes.*)

The usual fare is bread, porridge and pulse. Chestnuts and other mast also form articles of diet in the few wooded districts which the country possesses. (L. T., 24.)

The following accounts relate to the years 1869 and 1870: In Guipuzcoa, the nurture is beans, cabbages, milk, chestnuts, and Indian corn cakes in place of bread. Meat is scarcely known; occasionally a small piece of bacon is attainable. (L. T., 38.) In Biscay, the food is "puchero," a vegetable soup composed principally of cabbage and beans. Lard is occasionally added, and sometimes even a scrap of meat or dried codfish. (*Ibid*, 40.) The beverage in Asturias and Guipuzcoa is cider; in Biscay, it was "chacoli," a thin mixture of wine and water. Of late years this is becoming replaced by the common wine of Navarra, etc. In Majorca, the diet is vegetables and bread. (*Ibid*, 32.) In Minorca, it is potatoes. (*Ibid*, 35.) In Alicante, it consists of a pottage of rice, beans and oil, with barley or maize bread, and occasionally a little codfish or sardine; but butcher meat is seldom enjoyed. (*Ibid*, 51.) In Valencia, the usual food is, at morning, a pilchard (salted) and bread; at noon, a stew of beans and potatoes, with pieces of bacon; and at night, the same as at morning or noon. These articles of diet are usually supplemented with thin wine and sometimes fruit. (*Ibid*, p. 54, and private information.) In Galicia and Asturias, the food is potatoes and vegetable soup, condimented with lard; also bread of rye or maize; sometimes a piece of pork. (*Ibid*, 20.) In Andalusia, corn bread; seldom meat. (*Ibid*, 49.)

Effectiveness of Labor.

In Galicia and Asturias a good workman is expected to plow about one-fifth of an acre per diem. (L. T., 20.) One laborer only is required to every six acres yearly. (*Ibid*, 24.) One man with two horses or mules can plow in two days six *fanegadas* or 1.237 acres, equal to about five-eighths of an acre per day. (L. T., 53.) Consult also pp. 28 and 50 for similar, though less definite statements.

This extraordinary degree of inefficiency is not the result of indolence. All writers, from Arthur Young to the present time, agree in giving the Spanish peasantry the credit for untiring industry and perseverance. It is rather the product of weak and insufficient food and lack of comfort. (See Arthur Helps on Brassey.)

Condition of the Peasantry.

Galicia and Asturias, 1870. Their houses of rough stone—mostly consisting solely of the ground floor—are poor and dirty, the same roof frequently giving shelter to the proprietor's family and to the produce of his farm, including his oxen, cows, pigs and fowls. Some of the better conditioned of the same class construct with wood an upper story to their houses, which serves for their dwelling and granary, in which case the lower part is occupied entirely by the live stock. (L. T., 20.)

Majorca, 1870. Their houses are wanting in accommodations. Their food is frugal; their dress modest. (*Ibid*, 32.)

Minorca, 1870 Their cottages are of a cleanness that is remarkable, being whitewashed inside and outside twice a month. Their clothing, bedding, etc, are also very clean. Their habits are moral and religious. All disputes settled by arbitration. (*Ibid*, 32.)

Guipuzcoa, 1870. They are badly housed and have none of the comforts of the English. The kitchen is black, dirty and full of smoke They dress in home-spun flax. (*Ibid*, 38.)

Alicante, 1870. They are clothed in the linen shirt and short, wide trousers of their Moorish ancestors. (L. T., 51.)

Valencia, 1870. The peasants live in small stone or brick houses of one story, and in mud huts with thatched roofs. Their donkeys and pigs occupy a shed at the back of the house; but all pass through one door. (L. T., 53.)

Biscay, 1870. They are housed in stone buildings with no comfort and scarcely decency. Stables for oxen and pigs on the ground floor; sleeping apartment above. Results: dirt, discomfort and fever. Home-spun clothes, the men cloth, the women cotton and flannel from abroad. Habits thrifty. The tenant farms descend regularly from father to son by force of custom. (L. T., 41)

Andalusia, 1870. The great mass of the country population are hired laborers. The Spanish peasantry are generally poorly housed, fed and clad. The country is still insecure, and abductions for ransom by

banditti are not unfrequent. (*Ibid*, 45.) The British Consul at Cadiz, under date of February 15, 1865, says :

"Property and life are much more secure throughout the country than they were twenty years ago. Robberies are very much more rare ; the police, and especially the rural police (*gens d'armes*) in the provinces, are in general respectable officials, and are becoming useful and effective. In numerous small towns (I speak of Andalusia especially) they are active, earnest and conscientious local magistrates, quietly doing a great deal of good." (B. C. R., 1865, 96.)

The travelers' guide-books of recent dates, which are pretty good authority on the subject of personal security, agree in stating that brigandage and all molestation on the highways have wholly ceased. This happy result is attributed indirectly to the general improvement of affairs in Spain, and directly to the *guardas civiles*, a body of police or *gens d'armes*, selected from the veteran corps in the armies, and composed of men noted for high moral traits and physical pre-eminence.

Concerning the tendency of thought among the peasants, it is stated that :

"Socialistic and communistic doctrines are spoken and spread in Andalusia where the peasantry, though very bigoted, are argumentative and of an independent turn of mind. If ever Protestantism, in some shape or other, be put before the Andalusian, it will spread like wildfire, for it exactly suits his mode of thought." (L. T., p. —.) Socialism is gaining ground among the laboring classes of Andalusia. (*Ibid*, p. 51.) "Spain has a peasantry superior to that of most European countries ; but no middle class."—*London Economist*, January 5, 1867.

The military conscription, which is compulsory in Spain, is perhaps, the most oppressive institution against which the peasant has now to struggle.

Illiteracy and Education.

The following table shows the condition of the population of all Spain in these respects in the year 1860 :

Classes.	*Males.*		*Females.*		*Total.*	
	Number.	*P. C.*	*Number.*	*P. C.*	*Number.*	*P. C.*
Able to read and write.	2,414,015	15.4	715,906	4.6	3,129,921	20.0
Able to read only.....	316,557	2.1	389,221	2.4	705,778	4.5
Not able to read or write	5,034,936	32.1	6,802,846	43.4	11,837,782	75.5
Total.....	7,765,508	49.6	7,907,973	50.4	15,673,481	100.0

Owing to the ecclesiastical policy popular education showed no perceptible progress in Spain until about the year 1868, since which time it has made considerable strides. (*A. G. Fuertes, U. S. Consul at Corunna, October* 1, 1873.)

In 1797 only 393,126 children attended the primary schools of Spain and these were very imperfect.

Up to 1808 public education was entirely in the hands of the ecclesiastics.

Until 1838 there was scarcely any progress.

In 1848 the number of pupils attending all the schools was 663,711.

On January 1, 1861, the number was 1,046,558, as follows: Private schools, superior, elementary and mixed, 3,800 with 134,383 scholars; public schools, same classes, 18,260, with 912,175 scholars.—*Martin.*

It is believed that since 1861 the number of pupils has fully doubled. For a summary of the extremely liberal provisions for public education since 1861, consult U. S. Rep. Com. Education, 1871, p. 477.

Wages.

Years 1787–89. (Arthur Young.) Wages near Esparagara, spinners, six cents a day; carders, eleven cents; lace-makers, nine cents and food. Near Gerona, laborers twenty cents, without food. Near Barcelona, laborers, twenty-five cents a day, without food; highest, thirty-three cents, lowest, twenty-two and a-half cents.

Year 1864. (Com. Rel., 1865.) Wages in Bilboa, day laborer, 20c.@25c.; mechanics, 40c.@45c., without food.

Year 1864. (Com. Rel., 1865.) Since 1854, a notable rise in wages in Bilboa: Day laborers now, 55c@70c.; mechanics, 95c.@$1.25 without food.

Years 1869 to 1871. (Land Tenures, pp. 20, 24, 32, 38, 40, 45, 51 and 53. Com. Rel., 1871, p, 1010.) The following table gives the wages current in various provinces of Spain:

Daily Wages of Agricultural Laborers, without Food, 1870–1.

Provinces.	Men.	Women.
Galicia and Asturias	24 @ 28 cents.	14 @ 20 cents.
Asturias	25 @ 35 "	.. @ 20 "
Majorca	20 @ 30 "	10 @ 15 "
Minorca	.. @ 24 "	.....
Guipuzcoa	.. @ 30 "	16 @ 20 "
Biscay	.. @ 40 "	20 @ 25 "
Andalusia	40 @ 50 "	.....
Ilicante	25 @ 30 "	10 @ 15 "
" spade work	40 @ 50 "	.....
Valencia	25 @ 35 "	.....
Murcia	.. @ 28 "	.....
Spain generally *	30 @ 50 "	.....

* This last and probably unreliable line is from the C. R., 1871, p. 1010. The same authority quotes mechanics' wages throughout Spain at 40@75 cents per day, which is undoubtedly below the truth. It states the working hours in summer at fourteen, and in winter ten, which is probably correct.

DAILY AGRICULTURAL WAGES, WITH FOOD, 1870–1.

	MEN.	WOMEN.	BOYS.
Asturias	.. @ 12½	.. @ 07½	.....
Majorca	.. @ 10	.. @ 05	.....
Minorca	.. @ 15	.....	.....
" harvest, long hours	36 @ 45	.....	.....
Guipuzcoa *	12 @ 16	.....	05 @ 06
Biscay *	.. @ 20	.....	03 @ 04
Andalusia	.. @ 20	.....	.....
Murcia	.. @ 14	.....	.....

From these tables it would appear that in some places probably throughout Spain, wages continued, from the close of the last century to about the year 1855, without material change; but that since the last named date they have doubled. Whether this is due to the great ameliorations set on foot at that time in Spain, or to other causes cannot be determined in this place.

EMIGRATION.

During the years 1840 and 1841, at least 20,000 agricultural laborers left Valencia for Algiers. (*Macgregor*, 1015.) The immigration into the Argentine Republic (Buenos Ayres), which up to year 1862 was less than 7,000 persons a year, rose to between 10,000, and 12,000 persons in 1863 and 1864, and to over 40,000 persons in 1870. About 15 per cent. of of these persons in 1864 and 1870 were from Spain. (*Private information.*) There are now nearly forty agricultural colonies in the Republic. Of these, twenty have been formed since 1870. Many of the agriculturists are from Spain. The immigration of Spaniards into the United States, from 1820 up to and including 1870, was 23,504, and since 1870 has been as follows:

1871	558	1873	546
1872	595	1874, about	500

Large numbers of Spanish emigrants go to Cuba and South America, whence a few afterwards find their way to this country. In 1870, there were 3,764 natives of Spain residing in the United States.

I know of no statistics which show the total emigration outward from Spain, but it must be considerable. In Galicia and Asturias it is reckoned at 60,000 to 70,000 per annum, or 2½ per cent. of the population. (L. T., 20). One half of those from Asturias go to Spanish colonies. (*Ibid*, 24.) From Murcia 1,000 persons a month during six months of the summer and fall of 1869, went to Oran, coast of Africa. (*Ibid*, 28.) In the Balearic Isles emigration is not common, and the military conscription the principal cause. (*Ibid*, 32.) From Guipuzcoa there is a considerable emigration mainly to South America. The emigrants go chiefly by way of France. Cause, want of work. (*Ibid*, 38, 39.) From Biscay a large

* Guipuzcoa; boys $20@$30 a year, with food and lodging. Biscay, $15 a year, same.

emigration, which has been gradually increasing during the past fifteen years, occurs to South America, chiefly to Buenos Ayres and Montevideo. The local government has not been able to restrain this drain of population. (*Ibid*, 40.) From Andalusia emigration is rare, chiefly from Almeria and only in years of great drought. (*Ibid*, 45.) From Alicante, in years of drought the emigration to Africa is considerable. Many return when the weather (and, I suppose, their fortunes) improve. In good years they do not emigrate. (*Ibid*, 51.) The Valencians rarely emigrate. From the towns on the coast they frequently go over to Algiers and Oran for the harvest, and afterwards return home. (*Ibid*, 53.) The army and navy in the West Indies, and especially Cuba, constitute a regular drain upon the population by robbing it of its most energetic elements.

The American Consul at Corunna, under date of September 30th, 1870, says that 140,000 emigrants have left that district (in Galicia), for South America and Cuba within a few years, and that 4,000 to 5,000 more bound to the same ports sail yearly from Corunna. "The agents at this port are always willing to offer them passage, to be paid in small installments. Repeated applications have been addressed to this Consulate regarding the emigration to the United States. The applicants are generally all handsome and remarkably healthy young men, used from their infancy to farming and field labor, as well as to mechanical pursuits and are withal of an excellent moral conduct and pleasant disposition, but as they are too poor to pay for their passage, I could offer no inducements to them." The same Consul writes in 1873, that he had induced a Liverpool shipping house to send some steamers to Corunna for the United States, and that they had arrived and taken out to New Orleans a large batch of respectable young field laborers.

Prices and Rents of Land.

It is almost impossible to make anything out of the fragmentary and loose evidence on this point contained in Arthur Young and *Land Tenures*, the best authorities for the latter half of the last and present centuries, respectively. Roughly speaking, arable land seems to be worth at the present time from $70 to $125 an acre, and in the *huertas* of Valencia as high as $500 to $1,000 an acre, the latter price being quite common. Rents range from 3 to 3½ per cent. on the value of the property (L. T., 41), and are stated to be on all the lands in Spain, including, I suppose, the barrens, from $2 to $4 an acre (L. T., 18), and on the irrigated *huertas* of Valencia, $20 to $35 (*Ibid*,) the common rate being about $30 an acre. (L. T., p. 54.)

These prices and rents do not appear to differ materially from those quoted by Arthur Young, nearly a century before. (See Young, ii, p. 326 and elsewhere.)

I take it that, at the rents quoted above, the tenants pay the taxes; yet as the following passage occurs in *Land Tenures*, p. 56, relating to Valencia, this point does not seem certain :

"The taxes on landed property are for account of the landlord, and *if the Government taxes the land, for a larger sum than it really* produces, then the landlord pays only to the extent of the rent and the surplus is paid by the tenant and is denominated as colonization." Spoliation were a better name.

TAXES.

Transfer and succession duties on land have already been adverted to. Although there is some discrepancy in the accounts, all agree in representing these dues as exceedingly onerous.

"The cost of registration is, in the first place, a Government transfer duty of 3 per cent. on the price in cases of sale or barter; 10 per cent. in cases of donation *inter vivos* (during life), and from 1 to 10 per cent. on successions, according to the nearer or remoter degree of relationship between the deceased proprietors and the heirs; inheritance from ascendant to descendant is free of duty, and on a lagacy to very distant relations or to mere friends, being strangers in blood, the duty is 10 per cent. The Registrar's fee varies according to the length of the deed inscribed, but it never exceeds 3 per mil (3 cents on $10) on the price or value of the property." (L. T., 44.)

Such heavy taxes and fees would seem to amount virtually, to a prohibition on the sale of land and must have very injurious effects upon agriculture.

The taxes levied in Spain are general, provincial and municipal. (Com Rel., 1856, p. 56.)

The municipal taxes consist partly of octroi duties. For example, in Bilboa and possibly all over the country, the octroi duties are: ale 2 cents per *pound*; brandy, 4 cents per *pound*; oil, 20 cents per arroba of 28 pounds; salt, 30 cents per fanega of 110 pounds, beside others. (Com. Rel., 1865, p. 190.) The Galicians are taxed on almost everything they possess in the way of property: land, labor, food and raiment. (Com. Rel., 1871, p. 1008.)

Similar charges are exacted in Cadiz and on foreign products which have paid duty as well as on domestic. (Com. Rel., 1866, p. 222.)

Heavy taxes are also spoken of in Valencia. (L. T., 54, § 13.)

The General Government levies export duties (Com. Rel., 1873, p.; 961) also import duties, direct taxes on land, mines, industries, commerce, mortgages, excise, tolls, stamps, railway passengers, and miscellaneous. It derives revenues from the following monopolies: tobacco, salt, gunpowder, lotteries, mints, military establishments, post office and miscellaneous, and from the following domains: mines, property of the State, clergy and provinces, besides a revenue from the colonies. The total annual revenues of the General Government during the period 1865–70 were estimated in the budgets at between $107,000,000 and $138,000,000 per annum. This would amount to an average of about $7 per capita of population.

If the provincial and local taxes be added to these, the total bur-

den of taxation would be exceedingly onerous — especially when the industrial condition and efficiency of the country, as compared with other countries at the same period, is taken into consideration.

"The direct tax on real property, on agricultural produce and on cattle, has, during the last twenty years, nearly doubled, throughout the whole of Spain.

1846 to 1848,	it amounted	to	$12,500,000.
1849 to 1855,	"	"	15,000,000.
1856 to 1857,	"	"	17,500,000.
1858 to 1863,	"	"	20,000,000.
1864 to 1866,	"	"	21,500,000.

The same tax levied by the local authorities throughout Spain, for provincial and municipal purposes, has risen, during the same period, from $1,750,000 to $4,434,585." (Br. Con. Rep. 1866–5, p. 375.)

Interest.

In the year 1545, Charles the Fifth fixed the legal rate of interest in Spain and the Low Countries at 12 per cent. (*N. Y. Social Science Review*, 1865, pp. 362–3.) From that time until toward the close of the last century, the market rate of interest in Spain continued to fall, not so much from increased profits or security as from an increasing absence of opportunities for the investment of capital. This is proved by the fact that while generally the market rate of interest fell, the rate on Government securities rose.

At the time of Arthur Young's travels the market rate on landed security in Catalonia was 8 to 10 per cent.

Since that time the usury laws have been entirely abolished, and now interest is left free to be determined by the contracting parties. (L. T., 24.)

The prevailing rates on landed security about the year 1870 were from 4 to 5 per cent. per annum in Biscay and the Balearic Isles, the two extremities of Spain (L. T., 31, 37, 40), to 10 or 12 per cent. in Murcia. (*Ibid*, 28.) In the rest of the provinces, and Spain generally, it appears to be from 6 to 10 per cent. (*Ibid*, 18, 20, 24, 44, 50, 53.)

On the security of growing crops, or personal security the rates are most frequently 30 to 40 per cent., though of course they vary with the degree of risk in each case. (*Ibid*, 18, 24, 44.)

According to the quotations of the Madrid Bourse, at the close of the year 1874, Government securities were at prices that yielded interest at the rate of from 12 to 20 per cent. per annum.

Code of Law—Credit—Debt—Executions.

"The habits, customs, laws, have accumulated from the earliest ages, —Gothic, Christian, Jewish and Moorish,—forming an inextricable web which no legislator has attempted to unravel. Codification has been often talked of, and even attempted, and as yet produced nothing. The consequence is that most Spanish proprietors are perpetually involved in law

suits, which are lost and won, and lost again, going from one province to another and appealing to different courts and tribunals, one after the other." *H. B. M. Sec. of Leg. Percy Ffrench, Madrid, December* 7, 1870. (L. T., 19.)

For organization of courts of law and proceedings on judgments and evictions, see L. T., 26.

There are no special courts of bankruptcy. (*Ibid.*) "No questions are submitted to jury." (*Ibid.*)

Agricultural banks on the German plan have been tried but failed. (L. T., 55.) The system of legal procedure against debtors is the great drawback to credit based upon land. Even lending money upon mortgage is dangerous. (L. T., 44 and 47.) In many places money on land is only to be had on a sale *á retro*, or *á remoré* (L. T., 47), which seems to be a sale with power of redemption.

The laws give the landlord to whom rent or allowances for deteriora tions are due, a preference over other creditors to the extent of the cattle, household effects and other moveables found upon the property (L. T., 26, 34, 38 and 48); but not the mules, horses, plows, or carts; which appear to be exempt from execution. (*Ibid*, 51.)

A custom is said to exist in Valencia which is peculiar, and as it may be common elsewhere in Spain, and has a bearing on the tenure of land and security, credit and interest, I insert an account of it here:

"When an eviction occurs (generally a rare thing in the agricultural parts of Spain), if the landlord does not pay the colonist or tenant the value of the buildings (erected by the latter), the tenant pulls them down and carries away the materials; this, however, rarely happens." (L. T., 56.)

Common Roads.

"Owing to the badness of the roads and their unfitness for carriages, the principal carriers of merchandise are the *arieros*, or muleteers, who traverse the country in all directions along beaten tracks, many of which are accessible only to them. * * * Three-fourths of the entire inland traffic in corn is carried on by their means. Recently, however, wagons have begun to be introduced." (M'Culloch, 11, 839.)

This was the condition of affairs described in 1844.

Under date of July 1, 1865, the British Secretary of Legation, at Madrid, wrote as follows:

"Even the few main roads (common roads) which exist, are insufficiently provided with bridges, and it is not an uncommon sight to see eighty or ninety "carros" or country carts laden with agricultural produce, detained on the banks of a flooded river until able to ford, sometimes for three or four days. * * * Fifty years ago the internal communication was entirely carried on by means of mules, and few, if any roads existed." (*Br. Rep. Sec. Leg.* 1866, *p.* 184.)

COMMON ROADS IN 1860.

	KILOMETRES.	MILES.
First class	9,097	5,640
Second "	1,550	961
Third "	629	390
Total	11,276	6,991

"Also in course of construction 4,276 kilometres or 2,651 miles. Amount expended on roads in 1861 and 1862, $14,735,829." (*Ibid.*)

Since the conclusion of the civil war, the Government has constructed upwards of 10,000 miles of turnpike roads, exclusive of Biscay, where the roads have been built by the local authorities. (Br. Con. Rep. 1865, p. 83.)

A better view of the progress that has taken place is afforded by the following:

TABLE SHOWING THE LENGTH AND CONDITION OF THE VARIOUS CLASSES OF COMMON ROADS IN SPAIN IN THE YEAR 1867.

CLASSES.	KILOMETRES.	MILES.
First class roads	7,339	4,550
Second " "	9,566	5,931
Third " "	17,766	11,015
County "	4,540	2,815
Total	39,212	24,311

Of the above roads 12,342 miles were built, 2,087 miles in course of construction, and 9,882 miles projected in 1867. (Br. Stat. F. C. xii, 292.)

CANALS AND SLACK-WATER NAVIGATION.

Since the destruction of the Spanish forests, such of the rivers of Spain as were navigable before, were rendered unnavigable. Of these only the Tagus and Guadalquiver had been rendered partly navigable up to the year 1844. (M'Culloch.)

In 1871, owing to recent improvements in the river channel, vessels drawing from 16 to 18 feet of water could ascend the Guadalquiver to Seville. (C. R. 71, 1028.)

I have no other advices with respect to the progress of slack-water navigation in Spain. Of the canals of Spain, glowing accounts in general terms are to be found in many descriptions of the country (*e.g.* Appleton's Cyc., xiv, 805, Old Ed.), but I cannot find sufficient basis for them. There appear to be but three canals of any importance in Spain, and the aggregate mileage of the three is not over 300. These are 1. The Ebro Canal, in Arragon, from Tudela to Santiago, 41 miles below Saragossa. It was built in the reigns of Charles III, IV and V, is about 85 miles long and is navigable by barges, and used also for irrigating purposes. 2. The canal in Old Castile from Segovia, past Valladolid and Palencia, to Aguilar del Campo, and thence to the Bay of Biscay, with a way branch

to Rio Seco and another to Bourgos; commenced in the year 1753. 3. The Urgel Canal in the Gerona district of Catalonia. These canals are also navigable for barges. I do not find any other navigable canals of importance, and to say that the aggregate navigable canals of Spain are less than 500 miles in length would probably be largely within the truth.

Railways.

The following is a tolerably complete list of all the railways in Spain at the close of the year 1872, omitting branches and turn-outs:

Railways.	Miles Opened.
* Madrid to Saragossa and Madrid to Alicante	885
* Saragossa, Pamplona and Barcelona	385
* Barcelona to France *via* Figueras	109
* Northwestern Railway, Palencia and Corunna, Palencia and Leon *via* Gijon	158
* Medina del Campo to Zamora and Orense to Vigo (Medina to Zamora finished; Zamora to Orense not begun; Orense to Vigo unfinished)	56
* Cordova to Seville	81
Seville to Cadiz about	80
Branch to Moron about	20
* Cordova to Malaga	184
Branch to Antequera	
Branch Loja to Granada	
* Lerrida to Reus and Tarragona	50
* Aranjuez to Cuenca, 80 miles unfinished	....
* Aranjuez to Toledo	25
* Santiago, 27 miles unfinished	....
* Urgel Canal Railway	33
* East Coast Railway, Almansa† to Valencia and Tarragona	255
Tarragona to Barcelona	80
Madrid to Avela 40 miles, Avela to Medina del Campo 50 miles, Medina to Palencia 50 miles, about	140
Cordova to Alcazar (on Madrid and Alicante Railway), about	100
Badajos to Manzanares (on last named Railway), (this line connects with Lisbon, Portugal), about	250
Palencia to Burgos and Miranda, about	100
Bilboa, Miranda and Saragossa, about	150
Palencia and Santander, about	100
Barcelona and Gerona, about	60
Granollers to Junction with last named Railway, about	25
Barcelona and Reus, about	80
Miranda, Vitoria, Pamplona and Alfara, about	100
San Sebastian to Fuentarabia, about	20
San Sebastian, Guipuzcoa and Alsasua, about	50
Cartagena, Murcia and Chinchilla, about	150
Cordova to Belmez	45
Total miles opened	3,771

* Subsidized by Government.

† *i.e.*, from near Almansa on the Madrid and Alicante Railway.

The first railway, 15½ miles in length, was opened in 1848 from Barcelona to Mataro on the line now completed from Barcelona to Gerona. The following table shows the progress made from time to time since that year:

Close of the Year.	Miles Opened.	Close of the Year.	Miles Opened.
1848	15½	1862	1,694
1850	17	1863	2,208
1856	326	1864	2,525
1857	418	1865	2,982
1858	529	1866	3,184
1859	713¼	1870	3,380
1860	1,191	1872	3,711
1861	1,475	1874	4,100

From this table it will be observed that from 1848 to 1860, inclusive, a period of thirteen years, hardly 1,100 miles of railway were constructed in Spain; while from 1860 to 1874, inclusive, a period of fifteen years, nearly 3,000 miles were opened.

The area of Spain proper is 190,257 square miles, and of California 183,981 square miles. At the close of the year 1873 there were 1,368 miles of railway constructed in California; so that Spain with about the same area had nearly three times the railway mileage of California.

Beside the above there are many other roads in course of construction; for example: One from Seville to Lisbon *via* Merida and Badajos, the distance from Seville to Badajos, which is on the Portuguese border, being some 150 miles. (C. R., 1871, 1029.) One from Cordova to Belmez, 45 miles. (*Ibid.*) Opened in 1873. (C. R., 1873, 959.)

Concerning the roads which form the line between Madrid and the French frontier, the American Counsel at Bilboa, wrote in 1864 to the U. S. State Department, as follows:

"The Great Northern Railway, *Linea del Norte*, was opened (as a through line) on the 20th of August, 1864, for passengers and merchandise, from Madrid to Irun, on the French Frontier, where it connects with the railway to Paris. The line has been operated through Castile and other sections, for a considerable period; but the heavy character of the work—the engineering difficulties of carrying the line over and under the Pyrenees, which here break up into detached spurs—has long delayed the enterprise, lately so happily completed. The largest tunnel—in Guipuzcoa—is 2970 yards in length, and is 1869 feet above the sea-level. Besides this, there are 22 other tunnels, measuring in all, six miles. The Viaduct of Orinostiqui is 1120 feet long, and is carried over five arches, each having a span of 150 feet.

The construction of this road is a grand tribute to engineering skill, and will place Madrid within 35 hours of Paris." (Com. Rel., 1864, 279.)

HARVESTS IN SPAIN—RECENT YEARS.

1865. Grain abundant. (U. S. Com. Rel., 1866, 215.) One-third above average. (*Ibid*, 219.) Largest for many years. (*Ibid*, 1865, 175.)
1866. Grain hardly average. Potatoes deficient. (U. S. Com. Rel., 1867, 343.) Grain one-third less than in 1865. (Br. Con. Rep., 1867, 88.) Drought in Alicante. (*Ibid*, 1867–4, 133.)
1867. Grain moderately good. (Br. Con. Rep., 1868–7, 521.) Olives failed (*Ibid*, 1867–3, 87.) Also silk; this being the fifth year of failure. (*Ibid.*)
1868. Grain deficient. (Br. Con. Rep., 1867–8, 521.)
1869. Grain barely average. (U. S. Com. Rel., 1871, 1008.)
1870. Grain harvest good.
1871. Lemon crop in Andalusia the largest ever obtained. (U. S. Com. Rel., 1871, 1022.)
1872. Grain crops fair. (U. S. Com. Rel., 1872, 777.)
1873. Grain crops excellent. (U. S. Com. Rel., 1873, 938.)
1874. Grain crops good.

It is said that when the harvests are good in one section, the north or south of Spain, they are bad in the other; (Br. C. R., 1868–7, 521); but this statement must be taken with considerable allowance for error.

VARIETY OF AGRICULTURAL PRODUCTS.

The agricultural products of Spain are almost endless in their variety. The principal ones are as follows:

Grain Crops.—Wheat, maize, barley, rye, buckwheat, millet, oats, rice.

Green Crops.—Clover, grass, kitchen vegetables.

Root Crops.—Sweet and Irish potatoes, cassava, (*moniato* or *convolvolus batatas*,) raised in the Balearic Isles, and much used by the peasants for food; (L. T.,) liquorice; *catufas de Valencia;* peanuts.

Leguminous Crops.—Beans: 1 French beans; 2 string beans; 3 garbanzos; 4 carob-beans (the *algarobo* or *locust bean*, used as cattle fodder).

Fruits.—Apples, peaches, apricots, nectarines, pears, plums, cherries, grapes, oranges, lemons, limes, pomegranates, figs, olives, melons, berries, prickly pears.

Commercial Crops.—Sugar cane, cotton, esparto grass, hemp, flax, saffron, madder, red pepper, capers.

Nuts and Forest Products.—Chestnuts, walnuts, almonds, hazel-nuts, cork, oak and pine bark, acorns.

Animal Products.—Silk, wool, cheese, leather, eggs.

Liquids.—Wine, spirits, ale, cider, oil.

The grain crops will be more particularly mentioned hereafter. Of the other crops, those which demand attention on account of their importance, are oranges and lemons, figs, olives, esparto grass, almonds, cork, silk, wine and olive oil. Some idea of the production of these articles in Spain may be gathered from the list of exports hereinafter given, after due allowance is made for the quantities consumed in the country of their production.

PRICES.

The average of the prices of grain and meat in all the 49 departments of Spain in the month of July, 1874, is shown in the following table from the *Gaceta de Madrid:*

Average Prices in all the Provinces of Spain, July, 1874.

Wheat, (*Trigo*)	per bushel,	$1.57½
Barley, (*Cebada*)	"	.94
Rye, (*Centeno*)	"	1.00
Maize, (*Maiz*)	"	1.14
Rice, (*Arroz*)	per pound,	.05½
Large Chick Peas, (*Garbanzos*)	"	.06
Mutton, (*Carnero*)	"	.10
Beef, (*Vaca*)	"	.11½
Bacon, (*Tocino*)	"	.16½

Maximum and Minimum Prices in Various Provinces.

Wheat, *maximum*	per bushel,	$2.73
" minimum	"	.91½
Barley, *maximum*	"	1.49
" minimum	"	.50

It is not explained how these prices are determined, nor whether they are wholesale or retail; but I take it they are determined by public sales at market towns and at wholesale. The difference in prices in the various provinces, ranging from 91½c. to $2.73 per bushel for wheat, and 50c. to $1.49 per bushel for barley, show that, notwithstanding numerous railways, there still exist in Spain obstacles to the mobilization of breadstuffs which should demand the serious attention of the Government. It can hardly be due merely to the cost of transportation by railway that wheat and barley are three times as high in one province as another, and the tables published every month in the *Gaceta* show this to be the case, more or less, throughout many years. Spain is an extensive country, and as yet comparatively destitute of water-ways and other cheap modes of carriage. Still, 500 miles by rail will carry a bushel of wheat from one end of the country to the other, and unless the extreme prices quoted are in places as yet remote from the established railway lines, or octroi duties hinder the free circulation of commodities, I am at a loss to account for the disparities shown in the prices of the principal edibles.

COMMERCIAL POLICY—CORN LAWS—TARIFFS, ETC.

The severe restrictions which formerly characterized the Spanish commercial policy have been much modified of late years.

Until 1865 the *exportation* of breadstuffs, with occasional exceptions at long intervals, was prohibited, except to the colonies. (U. S. Com. Rel., 1866, p. 215.) I find, however, that in 1860, 1861 and 1862 there were, comparatively speaking, considerable exports of grain and flour from Spain to England, and I infer from this that the harvests of

those years were unusually abundant in the former country. Although the prohibition to export breadstuffs appears to have been removed in 1865, there only appear to have been considerable exports of those articles, since that date, in 1866, 1867, 1872, 1873 and 1874.

The principal features of the regulations with regard to the *importation* of breadstuffs appear to have been as follows:

1849. Act of July 17 prohibited imports of breadstuffs except at periods of scarcity. (Com. Rel., 1862, 220.)

1856. Grain crop deficient. Decree of May 13, 1857, admitted breadstuffs free until December 31, 1857. Decree of September 16, 1857, extended the time until June 30, 1858. Breadstuffs imported from France, Morrocco, Egypt, England and the Baltic. (Com. Rel., 1858, pp. 99–100.)

1863. January 1, new tariff. Metrical system introduced at custom houses. Octroi duties abolished and tariff increased on principal "tropical" imports, such as tea, coffee, etc. Tariff schedule simplified, but rates not lowered; on contrary, raised. Importation of breadstuffs still prohibited. (Com. Rel., 1863, 217.)

1865. April 1, regulations regarding imports of flour into colonies. June 28, other regulations, to wit: heavy discriminating duties on foreign flour into colonies. For example, duty on American flour into Cuba $9.50 per bbl.; on Spanish, $2.25. (Com. Rel., 1865, 176.)

1867. Duties on agricultural implements reduced to one per cent. in Spanish and one and one-fifth per cent. in foreign vessels. (*U. S. Monthly Statistics, November*, 1867.)

1867. July 1, importation of grain still prohibited. (Br. Con. Rep., 1867, 228.)

1867. August 22, decree admitting breadstuffs as dutiable articles for four months. October 25, time extended to June 30, 1868.

1868. January 11th and 17th, wheat and other alimentary substances admitted *free*. April 22, free entry of above articles extended to December 31, 1868.

1869. July 12, new tariff in force from August 1. Duties reduced on certain classes of articles about five per cent. Premium of $3.50 per 100 kilogrammes on exports of sugar refined in Spain. *Discriminating duties abolished.* Duties on agricultural implements one per cent. *ad valorem.* Duties per 100 kilos on rice, cleaned, $1.60; oats, 52c.; barley and maize, 45c.; wheat, 60c.; and peas, beans, etc., 60c. On flour 50 per cent. in addition to the grain of which it is made. (For full schedule, see *U. S. Monthly Statistics, July*, 1869.)

1873. Breadstuffs still permitted to be imported.

1874. " " " " "

COMMERCE.

As increase of commerce is far from being a necessary indication of increase of wealth, I do not offer as evidence of progress in Spain the increase which has lately taken place in her commerce, both foreign and domestic. But as I wish to show the character of her foreign commerce, particularly the exports, and still more particularly the exports of agricultural produce, I herewith append a complete table of the exports of 1872, and such other statistics on the subject as will tend to show the nature and extent of the agricultural and mineral products of Spain.

Table Showing the Quantities of the Principal Articles Entered for Exportation at the Custom-Houses of Spain (including the Balearic Isles) during the Calendar Year 1872.

Principal Articles,	*Quantities.*	*Principal Articles.*	*Quantities.*
Olive oil, pounds	42,187,505	Wheat flour, lbs	10',379,672
Spirits (aguardiente), gallons	1,552,367	Soap, lbs	10,460,624
Preserved food, pounds	4,673,055	Wool, raw, lbs	9.708,472
Corks: manufactured. M	1,015,312	Legumes: carob beans, lbs	16,881,755
in slabs, lbs	3,212,532	garbanzos, lbs	7,576 205
in pieces, lbs	1,248,643	beans, lbs	646,672
Esparto: crude, lbs	104,789,203	French beans, lbs	1,338,113
manufactured, lbs	6,201,923	Metals: quicksilver, lbs	4,180,946
Spices: anise, lbs	1,379,697	copper, ingots, lbs	780,960
saffron, lbs	174,900	iron, lbs	12,476,053
cumin, lbs	458,858	lead, lbs	207,701,747
pepper, ground, lbs	846,270	Ores: zinc, lbs	73,596,800
Dry Fruits: almonds. lbs	8,229,437	copper, lbs	584,987.900
hazel-nuts, lbs	12,257,696	iron, lbs	1,578,831,800
peanuts, lbs	4,278,446	other, lbs	105,015,984
raisins, lbs	110,471,456	Paper, lbs	4,304,582
all other, lbs	10,190,715	Soup pastry (maccaroni, etc.), lbs	5,139,497
Fresh Fruits: lemons, lbs	15,847,236	Licorice: root, lbs	13,719.741
oranges, M	547,400	extract and paste, lbs	1,604,931
grapes, lbs	9,620,080	Salt, lbs	328,908,136
all other, lbs	2,485,767	Silk, raw, lbs	309,661
Cattle, number	246,946	Wines: white, gal's	1,250,200
Grain: Canary seed, lbs	977,051	common, gal's	24 564,700
rice, lbs	10,934,605	do. of Catalonia, gal's	2,645,400
oats, lbs	3,472,341	sherry and port, gal's	9,120,400
barley, lbs	11,862,480	Malaga, gal's	567,000
rye, lbs	6,394,923	other sweet, gal's	43,000
wheat, lbs	113,809,762		

The most valuable articles of export at the present time are, 1. Wines; 2. Metals and ores; 3. Fruits; 4. Breadstuffs: 5. Oil; 6. Cork; 7. Cattle; 8. Salt; 9. Wool; 10. Esparto; 11. Silk; and 12. Spirits; and generally in the order named.

Wines.—The export of wine consists chiefly of sherries, which had usually amounted to some 8,000,000 or 10,000,000 gallons per annum, but in 1873 rose to 15,000,000 gallons, and of common red wines, which had usually amounted to some 25,000,000 gallons per annum, but in 1873 rose to 40,000,000 gallons. The following remarks on these two classes of wine will doubtless be read with interest:

About one-fifth of the entire shipments of so-called sherry wine from the Cadiz district consists of low and spurious compounds mixed in Spain, and worth in Cadiz from $50 to $100 per butt of 30 arrobas, say, net, 100 gallons. About two-fifths consist of ordinary sherry, worth from

$125 to $225 per butt. About three-tenths consist of good sherry, worth from $225 to $350 per butt. The balance, one-tenth, consists of superior sherry, worth from $350 to $1,000 per butt.

The best wines come from the district between Port St. Mary and Jerez, the low grades from other parts of Spain. The grapes are pressed with the feet, cased in sandals of esparto grass, and the wine has an earthy, tarry flavor, which is only removed from it after doctoring. The spurious compounds contain some of this wine, to which are added German potato-spirits, water, molasses, litharge and other adulterations. It is these two last grades of wine that the British chiefly sell and Americans buy. Indeed we buy from the British if even we buy in Cadiz; for there a large portion of the houses engaged in the trade are English. The wines are entered at our custom-houses as containing less than 22 per cent. of alcohol; while they really often contain 40 per cent.

There are four substances generally used in the manufacture of sherry. First, gypsum; second, a coloring substance; third, a sweetening substance; fourth, a spirituous substance. It has already been stated how these adjuncts are supplied to the low grade sherries; it only remains to state what substitutes for those mentioned are used in the preparation of the medium grades.

First, gypsum; second, color-wine, or wine boiled down to the consistency of sugar-house syrup; third, sweet wine, or wine made from raisins; fourth, brandy. Wine made in this manner is tolerably palatable. Most of the "crack" dry sherries belong to this class. They are entered at our custom-houses as containing not over 22 per cent. of alcohol. They really contain from 32 to 36 per cent.

The only really pure sherry wine is Amontillado, but as every sort of trash is called Amontillado, it is difficult for any one but an expert to distinguish the genuine article from the spurious. However, it is pretty safe to say that little or none of it comes to the United States.

Amontillado is not always the product of design. The quantity made in Spain is quite small, and the wine often the result of accident. To make this wine, the fruit is gathered some weeks earlier than for other sherries. The grapes are trodden by peasants with wooden sabots on their feet. The wine is then allowed to ferment for two months or more, when it is racked and placed in depositories above ground. Of a hundred butts but two or three may turn out Amontillado. This Amontillado is neither the product of particular vineyards, nor always the result of a careful or special mode of treatment, but the unaccountable offspring of several modes of treatment before, during and after fermentation. Fair Amontillado (by no means the best) is worth in Cadiz $1.50 to $2 a bottle. It probably cannot be purchased in the United States at any price. There is not a drop of spirits added to it, and no sherry wine containing foreign alcohol can be Amontillado.

I am assured by the Spanish Consul at Philadelphia that a very con-

siderable proportion of the so-called French claret wines, mostly the lower grades, are compounds, made of Spanish wines, imported chiefly at Cette. These wines are mixed with water, cheap spirits, a purple-coloring matter, and some other substances. They are then bottled, labeled with high sounding names and exported to all parts of the world as Bordeaux wines. In many cases the adulteration is carried so far that there is scarcely a trace of wine in the mixture, and what there is of it is the common *vino tinto* of Spain, worth about 22 to 23 cents a *gallon* in that country. (The total value of the 37,262,126 gallons of this class of wine exported from Spain in 1873 was $8,467,785.)

The following table shows the quantities of wines exported from the Peninsula of Spain and the Balearic Isles during the years 1872 and 1873:

Exportations of Domestic Wines from Spain in the Calendar Years 1872 *and* 1873, *respectively.*

Class of Wines.	1872. Gallons.	1873. Gallons.
White wines	1,250,153	1,409,110
Common wines	24,564,686	37,262,126
Ditto of Catalonia	2,645,432	2,713,083
Jerez (sherry) wines	9,120,389	14,840,609
Malaga wines	566,504	315,998
Rich wines (generosos) from various parts	43,001	120,518
Total	38,190,165	56,661,444

Breadstuffs.—This trade has increased enormously. Since the prohibition to export breadstuffs was removed in 1865, the shipments from Spain have increased over *four* times, or from about 5,250,000 bushels of wheat and flour to about 23,000,000 bushels.

Table Showing the Exports of Wheat and Wheat Flour from Spain:

Year.	Flour. Pounds	Wheat. Pounds.	Total. Pounds.	Year.	Flour. Pounds.	Wheat. Pounds.	Total. Pounds.
1860	96,800,000	No data.	96,800,000	1867	110,074,800	95,256,000	205 330,800
1861	160,600,000	"	160,600,000	1868	43,434,600	5,040,000	48.474,600
1862	94,600,000	"	94,600,000	1869	No data.	No data.	No data.
1863	84,620,800	4,043,040	88,663,840	1870	"	"	"
1864	78,234,200	2,430,300	80,664,500	1871	"	"	"
1865	87,687,600	35,940,000	123,627,600	1872	223,036,000	250,382,000	473,418,000
1866	167,312,200	147,336,000	314,648,200	1873	441,540,000	931,480,000	1,3730,20,000

The exports of breadstuffs other than wheat or flour are unimportant. The following tables gives the details for the year 1872 and 1873:

TABLE, SHOWING THE EXPORTS OF VARIOUS GRAINS AND LEGUMES FROM SPAIN, IN THE YEARS 1872 AND 1873, RESPECTIVELY:

BREADSTUFFS.	1872. POUNDS.	1873. POUNDS.
Rice	10,934,605	10,441,506
Oats	3,472,341	6,174,870
Barley	11,862,479	6,389,007
Rye	6,394,923	4,033,663
Soup pastes	5,139,497	4 723,532
Carob beans	16,881,755	8,783,780
Garbanzos (large chick peas)	7,576,205	7,885,100
Beans	646,676	1,255,465
French or Kidney beans	1,338,113	1,571,123
Total	64,246,594	51,258,046

The imports into Spain consist at the present time chiefly of tropical products and northern manufactures. Breadstuffs, chiefly wheat and maize, are only imported in years of scarcity. The following are the imports of breadstuffs in the year 1872 and 1873, respectively:

BREADSTUFFS.	1872. POUNDS.	1873. POUNDS.
Wheat	62,473,622	154,000
Other grain	17,062,228	4,509,690
Flour	16,179,207	153,000

MINING.

The revival of mining in Spain dates from the decree of Ferdinand VII., of July 4, 1825. (Br. C. R., 1868–5, 299.) That this judgment must be well based is very evident from the degree of progress shown in the following tables. The statement for 1780 is from Hoppensack, quoted by Macgregor. Those for late years are from the Br. Con. Rep., 1867–8, 560, the U. S. Monthly Stat., Mar., 1870, and U. S. Com. Rel., 1873, 964.

Table showing the number of metrical tons of (2,200 *pounds each*) *of Ore raised in Spain during the years named.*

Year.	Iron.	Lead.	Argentiferous Lead.	Silver.	Copper.
1780	9,000	1,600	.....	.....	15
1860	175,503	320,603	.....	4,230	224,152
1861	130,259	361,164	.....	3,005	246,611
1862	213,192	281,202	.....	2,523	313,913
1863	212,676	313,851	.....	3,060	343 181
1864	253,120	274,589	25,111	1,818	213,389
1865	191,684	271,318	19,323	1,125	273,184
1866	180,131	267,494	21,312	1,704	279,527
1870	436,586	318,985	33,248	2,679	395,695

Year.	Tin.	Zinc.	Cinnabar Mercury.	Phosphorus.	Antimony.	Manganese.
1780	....	125	900	.....	300	.....
1860	....	108,802	21,662	.....	....	28,863
1861	...	24,743	18,254	.....	....	14,071
1862	....	41,104	27,441	.....	....	6,459
1863	....	48,124	26,304	.....	....	14,860
1864	63	80,222	19,800	.....	74	22,246
1865	93	70,158	16,425	12,800	29	24,864
1866	30	73,423	18,547	9,304	..	39,624
1870	28	113,583	23,744	27,978	80	16,823

Year.	Alkali.	Alum.	Sulphur.	Coal.	Lignite.	Asphaltum
1780	.....	.....	.....	(1858, 170,000)	.....	....
1860	17,557	.....	23,045	321,773	17,523	....
1861	11,691	.....	23,148	331,055	22,292	....
1862	5,022	.....	12,639	360,246	28,696	....
1863	8,090	.....	11,982	401,301	50,302	....
1864	11,822	8,179	9,788	387,904	38,529	3,825
1865	7,667	9,044	10,708	461,396	34,455	795
1866	9,912	7,588	16,242	393,105	39,559	2,663
1870	7,975	13,250	15,156	621,847	40,095	478

The number of metrical tons of Salt produced in the Government Salt Mine was as follows:

Year.	Met. tons.	Year.	Met. tons.
1860	391,692	1863	187,271
1861	201,775	1869	170,000
1862	182,208	1870	37,917

The number of producing Mines of all kinds throughout Spain and the laborers and steam engines employed therein are as follows:

Year.	Number of mines.	Number of laborers.	Number of steam engines.
1860	1,988	33,297	39
1861	1,795	33,603	51
1862	1,386	36,635	52
1863	1,594	35,801	64
1864	1,842	37,201	76
1865	1,912	37,515	80
1866	2,283	38,483	94
1870	3,381	* 41.010	148

It needs but a cursory glance at these tables to perceive that of late years Spain has made great progress in this important branch of her national industries. Details of the smelting and refining establishments for iron and steel, lead, silver, copper, etc., none of which nor their products, have been included in the above tables, will be found in the

* To wit: men, 33,277; women, 1,508; boys, 6,225.

U. S. Com. Rel, for 1873. For account of power-looms, see Br. Con. Rep., 1867–8, 550; of fisheries, U. S. M. S., Mar., 1870; of manufactories in Catalonia, U. S. Com. Rel., 1862, 208; and 1864, 262.

Product of Breadstuffs.

The accounts of this product which have appeared from time to time vary so considerably, both as to total amounts and details that it is very difficult to reconcile them.

The earliest account relates to the last half of the seventeenth century and is, I believe, from Miguel Ozorio y Redin. It states the total product of grain to be 120 million bushels, two-thirds wheat and rye, and one-third barley and oats. The population is believed to have been at that time about seven and a-half millions. The product adduced would therefore equal 16 bushels per capita per annum, which seems excessive. The account is, however, not to be rejected as valueless. The numbers of the population supposed to have existed at that time are by no means certain; the consumption of grain was probably greater, and of meat, less than at more recent periods. The account may not relate to an average year, but an exceptionally good one; finally, it is to be presumed that, though not specified, the product of chestnuts, dry legumes and other substitutes for grain, is intended to be included in the principal articles mentioned.

The next account, quoted by Macgregor from the "Census and Returns" of 1803, is as follows:

Breadstuffs—Product of Spain, in 1803.

	Hectolitres.	Bushels.
Wheat	17,060,000	47,768,000
Barley	8,321,000	23,298,800
Rye	5,626,000	15,752,800
Oats, maize, rice, etc.	3,619,000	10,133,200
	34,626,000	96,952.890

We have here, a total product of some 97 million bushels of grain for a population of some 10,400,000 souls, an average of about nine and a-half bushels per capita. Bearing in mind that potatoes, chestnuts and legumes are omitted, I am inclined, for various reasons, to regard this estimate as substantially correct.

Mr. L. S. Sackville West, H. B., M. Secretary of Legation at Madrid, in reporting to his Government, under date of July 1, 1865 (Rep. Sec. Leg., 1866, 179), states that "fifty years ago, Spain, say with a population of 10,000,000, produced 38 million hectolitres (106½ million bushels) of grain." This statement corroborates the census and returns of 1803.

An estimate for the year 1849 appears in Mr. Joseph Fisher's work on *Food Supplies* (London, 1866), and gives the total product of cereals (omit-

ting maize) at 12,584,322 quarters, or say 100,674,576 bushels. Allowing 20 million bushels for maize and two million bushels for rice, we have a total in round figures of 123 million bushels of grain. The population at that time amounted to about 13,700,000, and the product of grain was therefore about nine bushels per capita, a proportion which appears to be substantially correct.

Says Mr. Sackville West: "In 1863, France produced * * * and Spain 66 million hectolitres of grain." As it is evident from the context and also from the fact that the cadastral census of Spain was taken in 1857, that that is the year to which Mr. West refers in regard to Spain, I have taken the liberty to so treat his statement. Sixty-six million hectolitres amount to 184,800,000, bushels, and this, among a population of 15,000,000, amounts to an average of about 12⅓ bushels each. If Mr. West's statement is applied to the year stated, 1863, when the population was a fraction over 16,000,000, the result would be an annual product per capita of about 11½ bushels. From both of these results I am inclined to believe that Mr. West's estimate includes potatoes, chestnuts and legumes. In such case I regard it as substantially correct.

For the year 1857 we have another account. This was given by no less an authority than the late Albany W. Fonblanque, the accomplished statistician of the British Board of Trade, and is published in the *Agricultural Returns* of H. B. M. Board of Trade for the year 1867. Ever since that year it has been regularly published in the Returns as the "estimated quantities of the principal kinds of corn and potatoes produced in Spain," and it therefore appears in the A. R. for 1874, over the signature of Mr. A. R. Valpy, Mr. Fonblanque's no less accomplished successor. Notwithstanding these high authorities and the official sanction which the publication of the account in such a work conveys, I am compelled to regard it as defective. It states that Spain produced in 1857, 168,140,692 bushels of wheat; of barley 76,427,587 bushels; and of rye, 24,727,483 bushels; together, 269,295,762 bushels of grain; an average of nearly 18 bushels per capita of population, to say nothing of maize and patatoes, which are important articles of consumption in Spain; nor of oats, rice, buckwheat, millet, chestnuts nor legumes—proportions that so radically differ from all other accounts as to lead to the suspicion that error has been committed in the conversion of the quantities.

For the year 1868 we have the account laid before the Statistical Congress at the Hague, by Mr. Samuel B. Ruggles, of New York. This is as follows:

Cereal product of Spain, with Balearic Islands, in 1868: wheat, imperial bushels, 87,732,150; rye, 44,427,940; barley, 47,731,500; oats (included with other cereals); buckwheat and millet, 22,975,300; maize, *nil;* rice, 2,000,000; total 204,866,890 imperial bushels. With the exception of rye which is over-estimated, and buckwheat and millet, the estimated product of which ought to be credited almost entirely to maize, I am inclined to regard Mr. Ruggles' account as substantially correct. The total sum

gives an average allowance of grain per capita of about 12½ bushels, which agrees with all of the estimates that are regarded as reliable.

For the year 1873, I have the following very explicit and detailed account, recently transmitted to me from Spain:

Account of the produce of Breadstuffs in Spain and the Balearic and Canary Islands for the year 1873.

Breadstuffs.	Bushels.	Breadstuffs.	Bushels.
Wheat	110,000,000	Rice	2,000,000
Barley	40,000,000	Buckwheat and Millet	5,000,000
Rye	20,000,000	Potatoes	25,000,000
Oats	3,000,000	Chesnuts	3,000,000
Maize	25,000,000	Dry Legumes	5,000,000
		Total	238,000,000

Reckoning the population in 1873 at about 17,200,000, the result is an average of all kinds of breadstuffs of 13.8 bushels per capita, and of grain alone 170,000,000 bushels, or about 9.9 bushels per capita. Allowing 23,000,000 bushels for the export of grain, the consumption would be 147,000,000 bushels, or 8.5 per capita.

I am inclined to believe that this account, though it agrees very well with those relating to previous years, underrates the true product of Spain, though perhaps only to a small extent. Altogether it is the best account we have, and must be taken as an exponent of Spain's present capacity to produce breadstuffs until a more definite account can be rendered. Grouping together such of the preceding accounts as seem reliable, we have the following comparative results:

Comparative Estimate of the Breadstuffs product of Spain at Various Periods.

Year.	*Grain. Bushels.*	*Potatoes, Chestnuts and Legumes. Bushels.*	*Total Breadstuffs. Bushels.*	*Population. Approximative*
1803	97,000,000	.....	.....	10,400,000
1849	123,000,000	.....	.....	13,700,000
1857	.....	.....	184,800,000	15,000,000
1868	205,000,000	.....	.....	16,700,000
1873	203,000,000	33,000,000	238,000,000	17,200,000

These results, in the transcendantly important department of agricultural production, show the same remarkable advance during the past twenty years as has already been noticed in other respects, and fully establish the claims set forth at the outset of this paper.

It will perhaps be noticed that, except as to exports in the year 1873, I have taken no notice of the imports and exports of breadstuffs. The reason for this was that among the periods under review relating to agricultural production, 1873 was the only year in which the foreign commercial movement of breadstuffs appeared worthy of note.

GRAVITATING WAVES.

By Pliny Earle Chase,

Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, January 1st*, 1875.)

In my various discussions of luminous and gravitating harmonies, I have shown many slight discrepancies, between theoretical and observed results, which are of the same order of magnitude as planetary orbital eccentricities. Although it would be unreasonable to look for any speedy and complete solution of those discrepancies, I think it right to try such questionings of nature, as seem likely to lead to a fuller understanding of the common laws of molar and molecular force.

The hypotheses of Newton and Le Sage seem necessarily to involve a repellent action of the æthereal waves between two bodies or particles, as well as a centripetal appulsion by the exterior waves. If the ratio of these activities is discoverable, it seems reasonable to look for it in the relative positions and motions of the three controlling bodies in the principal subdivisions of our system,—Sun, Earth, and Jupiter.

In the simplest form of gravitating or other central revolution, the tangential "lines of force" are continually deflected, by radial centripetal waves, so as to form a system of semi-circular undulations. The velocity of circular orbital motion communicated by any central force being represented by radius, (or twice the virtual centripetal appulsion), the length of the aggregating radial wave : the length of the deflected semi-circular wave : : $1 : \pi$. But the length of the wave of dissociation* : the length of the limiting wave of aggregation : : $2 : \pi^2$. Combining these proportions, we find that the length of the dissociating or repelling wave : the length of the primitive wave : : $2 : \pi^2$, or : : .0645 : 1. If the repulsion of the surfaces of two bodies from their common centre of gravity is $\frac{2}{\pi^2}$ of the appulsion towards the centre of gravity, the distance of the common centre of gravity from the principal centre of mass $= \left(1 + \frac{2}{\pi^2}\right) r = 1.0645\ r$.

The mean distance of Jupiter from Sun being 1117.87 r, the mass of (Sun ÷ Jupiter) should be, to accord with this hypothesis, 1117.87 ÷ 1.0645 = 1050.14.

I have already shown that the limit of dissociating velocity (v_0) for Jupiter and Earth, corresponds to the limit of planetary velocity for Sun, thus indicating an equality of radial and tangential action, such as we might reasonably have anticipated. If we adopt Cornu's determination of the

* Proc. Am. Assoc., Hartford Meeting, 1874; Am. Jour. Sci., "Velocity of Primitive Undulation," Nov. 1874.

velocity of light, so as to derive all our data from observations which are always susceptible of verification, we find the following accordances.

I. For Earth:

$$v_2 = \frac{2}{\pi} v_\rho = \frac{4r}{t} = \frac{15851}{24} = 660^m.46 \text{ per } h.$$

$$v_1 = \sqrt{2gr} = \sqrt{\frac{32\times 7925.5}{5280}} \times 3600 = 24{,}950^m.2 \quad " \quad "$$

$$v_0 = \frac{gt}{2} = \frac{v_1^2}{v_2} = \frac{32\times 43200\times 3600}{5280} = 942{,}545^m \quad " \quad "$$

$v_0 \div \sqrt{214.86}$ = approx. Solar $\sqrt{gr}$ at $\oplus$ = $64{,}302^m$ " "

Multiplying by 8766^h and dividing by 2π we get, for an approximate estimate of Sun's distance, $89{,}711{,}000^m$ (α).

The distance corresponding to Cornu's estimate of the Solar parallax (8″.86) is $(206264.81 \div 8.86) \times 3962.75 = 92{,}255{,}000^m$ (β).

Dividing (β) by (α) we obtain 1.0284, which is nearly equivalent to $\sqrt{1.0645}$.* Therefore v_0 for Earth is nearly, if not precisely, equivalent to planetary velocity in a circular orbit at the centre of gravity of Sun and Jupiter.

II. For Jupiter:

The uncertainty of the elements in this case precludes the possibility of any minute verification of hypothesis, but it is evident that the point at which the gravitating waves must act, in order that the dissociating velocity of Jupiter $\left(v_0 = \frac{gt}{2}\right)$ may equal the limit of planetary velocity, must be at or near Jupiter's surface. For the mass of (Jupiter $\div$ Earth) $= \frac{1}{1050.14} \div 4.432 \left(\frac{8.86}{1000}\right)^3 = 308.92$. The apparent diameter of Jupiter is variously estimated, from 3′ 13″ to 3′ 25″.5 at Earth's mean distance from Sun. Dividing by $2\times 8''.86$, we find for diameter $(2 \div \oplus)$ 10.89 @ 11.60, and for g $(2 \div \oplus)$ 2.3 @ 2.6. The estimates for the time of rotation (t) vary between $17700^{sec.}$ and $17880^{sec.}$

Therefore:

$v_0 = \frac{gt}{2} = gt \frac{(32\times 3600)}{5280} = 888{,}219$ @ $1{,}014{,}283^m$ per h. The geometrical mean of these possible extreme values, differs from the value found for Earth by only 7–10 of one per cent. The other planets, both of the Jovian and of the Telluric belt, would all be dissipated and absorbed in their primaries before they had attained the dissociating velocity of Jupiter and Earth. This intimate dependence of planetary aggregation, dissociation, and rotation, upon Solar attraction, and the dependence of Solar aggregation, dissociation, rotation, and planetary revolution upon

* $\sqrt{1.0645} = 1.0317$.

the velocity of light, therefore point to the same unity of force as has been indicated by the modern researches in heat, electricity, and magnetism.

III. For light and Terrestial Gravity :

If g = equatorial gravitating velocity, and t = a sidereal year, $gt \div \sqrt{1 + \frac{2}{\pi_3}} = 365.256 \times 86400 \div 5280 \div \sqrt{1.0645} = 185{,}380\ m$ per second. This corresponds to the velocity of light, giving a Solar distance of $497.83 \times 185{,}380 = 92{,}287{,}700$ miles.

VI. Wave Lengths:

The primary radius, $1.0645 \times 92{,}255{,}000 \times 63360 \div 214.86 = 28{,}959{,}800{,}000$ inches. Dividing by the number of wave-lengths* in radius, 66456 $(10^{,11})$, we find for the value of one wave length, $u = \frac{1}{229131}\ in.$ The radial waves should be accompanied by deflected tangential waves of three kinds, viz. :

1. $w_2 = \frac{\pi}{2} u = \frac{1}{145869} in.$ = wave of simple rotation.

2. $w_1 = \pi u = \frac{1}{72934} in.$ = wave of circular orbit.

3. $w_0 = 2\pi u = \frac{1}{36467} in.$ — wave of virtual fall *doing work* = Solar orbital wave = $4\ w_2$.

According to Eisenlohr,† the wave-lengths in the diffraction spectrum are as follows :

Upper actinic,	$\frac{1}{143880}\ in.$
Lower actinic, or upper luminous,	$\frac{1}{71940}\ in.$
Lower luminous, or upper thermal,	$\frac{1}{35970}\ in.$

V. Miscellaneous :

Among other note-worthy accordances in this connection are the following :

1. The approximate equality of Mass $(♃ \div ☉)$ to distance fallen through in (time of fall to centre $\div$ time of circular revolution).

2. The equality of orbital *vis viva* in Jupiter and Saturn.

3. The equality in the ratio of orbital *vis viva* $(♆ \div ♁)$ to the ratio of orbital to radial waves $(w \div u)$.

4. The connection of Sun's radius, modulus of light, and the limits of the planetary system ; the velocity of planetary revolution and Solar rotation being equal at 37 ☉ ; v. of revolution at 37 ♆ $\left(= \frac{M}{2}\right)$ — v. of rotation at ☿.

5. The stellar-solar parabola, between α Centauri and Sun, and its relations to the planetary distances.

* *Loc. cit.* † Am. Jour. Sc. [2] xxii, 400.

AN OBITUARY NOTICE OF MR. JOSEPH HARRISON, JR.

By Coleman Sellers.

(*Read before the American Philosophical Society, February* 19, 1875.)

When we review the life of any prominent individual and attempt to analyze the motives that seem to have actuated him, and which may have led to his success, we can scarcely avoid noting a resemblance to other lives; we find the same results following the same general course of action in all. This orderly sequence of events leads us to think we are subject to some fixed law, with which law seemingly accidental causes may interfere to give endless variety in detail, yet not materially to alter the result. That the good and obedient son, the industrious apprentice, the faithful workman, should in time grow to be the much-respected and influential citizen, seems so natural and orderly that life in such a case appears as if "it was a sum duly cast up giving results in particular figures."

In rendering tribute to the memory of our late associate, Joseph Harrison, Jr., by reviewing the prominent events of his life and recording the results accomplished by him, the high position held by him in his latter days demands a careful consideration of the orderly growth of a life which had its beginning in the enforced economy and habits of industry of the apprentice and in a few years of home training.

So far as any chronological record of his life is needful, the task you have honored me by imposing on me is rendered easy by his own forethought in presenting to his children a well-written autobiography so clear and precise in its narrative that it is difficult to avoid the use of his own words in giving here the outline of his life. Previous to the War of Independence Mr. Harrison's ancestors seem to have been well-to-do; but his grandfather, who was a large land-holder in New Jersey, entered the army, and afterwards neglecting his personal affairs, died in 1787, leaving but little for his family. His son, Joseph Harrison, was sent to Philadelphia when fourteen years old, and was employed by Mr. Charles French, grocer, whose daughter he married in 1803. He seems to have been unfortunate in business, and the subject of this memoir was born, as he says, in the dark hours of his family history. This was on September 20th, 1810, so that Joseph Harrison, Jr., was 63½ years of age at the time of his death, March 27th, 1874.

In his youth he seems to have been fond of reading the few books at his command, and very early he evinced a strong inclination towards mechanical pursuits. Following this bent after what schooling he could obtain before he was fifteen years old, he was at that age indentured to Frederick D. Sanno, in the old district of Kensington, to learn the art and mystery of steam engineering. In about two years the failure of Mr. Sanno canceled his indentures. He considered the change that this necessitated a good thing for himself, as he was then enabled with some

experience to enter a better shop upon more advantageous terms. His second employer was "an uneducated Englishman, but a very good workman," and in his shop he soon became more proficient, and at the age of twenty, before he was yet free, he was made foreman of part of the establishment and had under him thirty men and boys. At the expiration of his apprenticeship to James Flint, he continued with the firm, then Hyde & Flint, for one year, and left them to take employment with Philip Garrett, a Quaker gentleman, who had a small shop for the manufacture of "small lathes, presses for bank-note engravers and the like." He remained with Mr. Garrett until 1833, then went to Port Clinton, Pennsylvania, to start a foundry for Mr. Arundus Tiers, with whom his father was engaged as accountant. This was the end of the varied experience as a mechanician preceding his career as a constructer of locomotives. In 1834 he was employed by William Norris, then engaged with Colonel Long in building locomotives (the design of the latter-named gentleman). Here he obtained his first insight into that branch of the mechanic arts that was afterwards to be his life-work. He seems to have considered this part of his mechanical education as of a negative character, as he said "he had been schooled in the midst of failures," so that when in 1835 he was engaged by Messrs. Garrett & Eastwick as foreman, and was intrusted with the designing of the locomotive "Samuel D. Ingham," he endeavored to avoid what he believed to be "the errors with which he had been made familiar." This engine was considered a success, and led to the construction of others like it. On December 15, 1836, he married Miss Sarah Poulterer, whom he had met in New York in January, 1835. After his marriage, in 1837, he became a partner in the firm of Garrett, Eastwick & Co., investing his skill, the only capital he had, in the venture. In 1839, when Mr. Garrett retired from business, the firm took the title of Eastwick & Harrison. In 1840, he designed an engine at the request of Mr. Moncure Robinson, of the Reading Railroad. This engine, named the "Gowan & Marx," "proved to be, for its weight (eleven tons), the most efficient locomotive for freight purposes that had been built anywhere." This event seems to have been the turning point in his life, for two Russian Engineers, Colonels Melnekoff and Kraft, were in America at that time studying the railway system of this country. They saw this engine and were so well pleased with its operation that they procured tracings from the drawings of it, and took them to Russia. This style of engine seems to have been adopted by the authorities in Russia, and Mr. Harrison was invited to visit that country, money being forwarded to defray his expenses. He was cordially received, and in 1843, in association with his partner, Mr. Eastwick, and Mr. Thomas Winans, of Baltimore, he concluded a contract with the Russian Government to build the locomotives and rolling stock for the St. Petersburg and Moscow Railway. This contract amounted to three million dollars; the work to be done in five years, it being conditioned that all the work should be done in St. Petersburg, by

Russian workmen or such as could be hired on the spot. It was at this critical period of his life that he experienced the advantages of his early training. The great work was to be carried on in a land where every kind of corruption was the rule; where all the subordinate officials of the land fed and fattened on the commissions collected from those who had contracts with the Government. The payments were to be made as the amount of work completed; inspectors were to examine into the work done, and report as to the correctness of the monthly statements. The inspectors, for a pecuniary consideration, were ready to endorse any statement, no matter how false, yet would threaten annoyance if they were not bribed. This, added to the trouble of working inexperienced hands, made the task of the contractors the more difficult. Mr. Harrison had been told by Count Bobrinski that the officials would wear them out long before the term of their contract was ended. The Count, meeting him in after years, spoke of the conversation and said the success of the American contractors had been a mystery to every one. They did not understand how that contract and subsequent ones could have been carried out without resorting to the usual practice of doing Government work in that country. In their efforts to act fairly and honestly in their work they seem to have been upheld by all the higher officers, and their course won the confidence and approval of the Emperor himself, who was a careful observer of the work as it progressed. In all of Mr. Harrison's successes under these many difficulties his character as a cautious, prudent and strictly upright man was manifest, and was clearly the outgrowth of his early training. The confidence inspired led to other contracts, as in 1850 to one to maintain the moveable machinery of the road already equipped by them for the term of twelve years. This contract bears date August 25, 1850, and the parties to it were Messrs. Joseph Harrison, Jr., Thomas Winans and Wm. L. Winans, the latter having purchased Mr. Eastwick's interest in the contract of 1843, previous to its completion. As an evidence of the Imperial favor, valuable diamond rings had been given to the members of the firm, and Mr. Harrison was made the recipient of the ribbon of the Order of St. Ann, to which was attached a massive gold medal, upon which was inscribed in the Russian language the words "For zeal." This honor was conferred upon him at the time of the completion of the bridge across the Neva, accomplished by the firm during the time of the first contract, which had been extended one year for this purpose. During Mr. Harrison's residence abroad he seems to have noticed with interest the effect of the art galleries on the working people, and when he returned home he at all times advocated the foundation of public art museums open to the people at all times, and was active in the establishment of one in our Park. He frequently expressed his opinion of the need of art culture in improving the taste of artisans and rearing among us competent designers. An appreciation of the beautiful prompted him to collect about him many paintings and other works of art, which served to beautify the home he soon built for himself in his native city.

It was in 1852 that he returned from abroad and located himself in Philadelphia to enjoy the rest from active business cares needful after his many years of labor. The ample means that had rewarded his enterprise abroad enabled him to gratify his taste for art and later to do good service to the world in his crowning achievement yet to be alluded to—his safety steam-boiler.

Soon after his return to America he built the house which was his home for the remainder of life. The planning and arranging of many of the seemingly minor details of this building gave him pleasing employment for some years. It was at this time that the writer became acquainted with him, was made aware of his mode of thought and his ability as a mechanic. He can bear testimony to the fact, of interest it may be to mechanics only, that hidden under the plaster of that house are very many ingenious devices to insure stability and to economize space by the use of iron in forms and shapes not commonly known to architects at that time. These were special adaptations suggested by a mind fertile in resources, familiar with the use of iron and possessed of a knowledge of how to form it and use it to good advantage.

He chose to invest much of his means in real estate, and numerous fine buildings which serve to beautify the city were erected by him. At one time he advocated the concentration of all the railroad termini at one central point in the city, and to combine with the depot commodious hotel accommodation. With this end in view he attempted to purchase land, not so much as a speculative movement as to render such a plan possible. It is believed that he felt disappointed when this scheme was shown to be impracticable. In this connection it may be well to mention that in 1860 he desired to return to Europe with his family, and upon the eve of his departure he sent a message to the writer requesting him to call to see him. He then said that he desired to tell one who understood him why it was that he was about to leave so pleasant a home. He spoke of the many plans he had had in view to benefit the city, and said with sorrow that he felt that his motives had been misconstrued, and in some respects his efforts had been failures on this account. He desired to go abroad, to be absent for some years; that while away his plans should be forgotten and when he returned he could begin again in some other direction. Previous to this, in 1858, he mentioned to his friends an invention he had made to obviate the danger of disastrous explosions in steam-boilers. Starting with the idea that the strength of any structure is the strength of its weakest point, he aimed to construct a steam-boiler built up of units of some given strength. He claimed that a sphere of metal, say of cast iron, might be formed with its walls not more than three-eighths of an inch in thickness and of such a diameter as would establish its bursting pressure at may be 1000 pounds per square inch. Such a sphere would doubtless be safe for the pressures usually required by users of high-pressure steam. He proposed casting these spheres in groups of two and four, uniting them in one plane by curved necks and making openings at

right-angles to these uniting necks in the form of half necks with rebate joints to match with similar joints on the other groups. A group of four balls might be called a unit, and a pair of balls a half unit, corresponding with whole bricks and half bricks in building usage. Each of these units would possess a strength measured by the strength of each individual ball or sphere forming part of the unit, and a boiler structure built up in any form and to any extent would have a strength identical with the strength of each unit used in its construction. As the various groups of balls were to be held together by bolts passing through the opening from end to end of the pile, it was presumed that these bolts would stretch under an unusual strain and thus permit a leak at the joint, so, making, as it were, a great many safety-valves to relieve the strain. It was of primary importance that the walls forming all the sides of these groups of balls should be of uniform thickness. To accomplish this result a knowledge of the founding art would be needed. When Mr. Harrison presented this idea to the public he had evidently carefully considered all the difficulties that would occur in the practical realization of it and in its introduction. He had already perfected his plans and was prepared to direct the preparation of the patterns from which these groups of spheres could be cast of uniform thickness of metal, on what is technically known as a green-sand core, so that the first group or unit cast was perfect in all respects. He had also matured a plan of dressing the rebate-joints in the groups by machinery, thus insuring accuracy of size and making the parts interchangeable, without depending on the skill of the workman.

The first boiler built on this plan was tried in the establishment of Messrs. William Sellers & Co., in this city. It was erected in the spring of 1859, and for many months supplied all the steam needed in that establishment. To avoid all risk from so novel an experiment the cast iron boiler was worked for several months at Mr. Harrison's own expense, fires being kept under the wrought iron boilers in readiness for use should the new one give out. It may be well to mention that from that time to the present writing, these boilers have been in constant use in the same place under some of the many forms afterwards designed. The invention of this kind of safety boiler marked a distinct era in boiler construction; and whatever may be the ultimate history of this invention, whether its use be continued in future, or it be superseded by other forms, it is nevertheless a well-established fact that its inception preluded all the forms of sectional safety boilers now in use which are presented, each with some special claim for efficiency, durability and safety. Mr. Harrison did not claim for his invention diminished first cost, nor did he anticipate any greater efficiency than was obtainable by any first-class boiler, but he was sure of a greater safety in the use of high-pressure steam and he thought that the use of his invention might render possible the safe employment of higher pressures, if desirable, than was before considered possible with any of the ordinary types of wrought iron boilers.

Had Mr. Harrison presented to the world no other work but this his life would have been justly classed among the benefactors of our race. As it was, this invention was a crowning achievement of a life full of usefulness.

Much of the detail of the machinery needed to produce these steam-generators was perfected during the years he was abroad, between 1860 and 1863, he returning to America in the summer of the latter year. After his return he erected a factory for the production of his boiler, and in the arrangement of this establishment he evinced mechanical ingenuity of the highest order. He introduced many novelties in the methods of founding; in modes of cleaning the castings and in the general system of proving the work when done. He aimed to so systematise the work as to dispense with skilled labor as far as possible, using machinery in its place.

As Mr. Harrison had passed through the various conditions of life as an apprentice, as journeyman, as foreman, and then as principal in his career as a mechanic, and had achieved proficiency as a skilled workman before the days of modern machine-tool and labor-saving appliances, he naturally believed such training to be the proper one for the youths of our day, and in a measure deprecated the practice of keeping young men too long at school if they looked toward success in the workshop. As this was emphatically announced in public near the end of his useful life, it may be well to give it more than mere mention. In the journey of life there are in the memory of all persons events which stand as landmarks on the road; certain points that appear prominently in view and are remembered at all times in their proper order. In looking backward along this road traveled but once, these important events are clearly seen, no matter how long the road may have been, and the more distant ones seem crowded in close proximity, the space between them having been lost to view, so that the sum of life seems made up of the strongly marked events only. If these events lead step by step towards affluence and position, they must seem to the traveler on that road to have surely marked it as the only path that could have led to such results. Mr. Harrison saw in his early application to the workbench, in his early industry grown to habit, in his enforced economy in boyhood, the foundation of own his success. He prided himself on his skill as a workman, and although he ceased to work with his hands when he took control of his greater enterprises, yet he felt that in learning how to work he had stored his mind with the knowledge of most use to him as a master-mechanic. Hence we are not surprised to hear him advise the need of early apprenticeship to those who desire to become mechanics. His expression, "In mechanical and other trades it is the education of the work shop and not the education of schools, that is most required," was prompted by the bias of his own career, and was strengthened by observation of the course of many others who, like him have, from rough beginnings, achieved distinction. His life, like the lives of those many others, was a long period of

study. He pursued such knowledge as he needed, because he did need it, and for its use to him he loved it. The varied incidents of his life abroad, the persons with whom he came in contact, aided his mental culture. His manual skill secured his advancement in the workshop. The knowledge he needed was obtainable from daily observations only ; it was not written in any book ; mere skill as a workman would not give him this knowledge, but it did give him opportunities of observation, and he was ready to avail himself of the fund of information so collected. His opinion in the matter of the education of mechanics has weight and needs careful consideration. He had but to point to his own career as an example to prove the rule he laid down. There are comparatively few of the youths of the present day who care to go through the years of apprentice life. The tendency of all modern schooling is to make tradesmen of them, not mechanics. Of these few who from strong inclinations would lead a mechanic's life but a still smaller proportion can find places in the work-shops of the land. Hence the need of schools that may take the place of these work-shops and give to our young men the very knowledge that Mr. Harrison claimed they most needed. He did not believe that mere manual skill would insure success ; he knew that much learning was needed, but he believed that knowledge was within the reach of every one who would diligently seek it. He says of himself that while quick to learn at school and was in some branches at the head of his class, yet strange to say he never wrote a composition at school, and did not write his first letter until after he was twenty years of age.

So far as technical education was needed by him in his career as a locomotive-builder, it must be borne in mind that it was in that direction unobtainable when he most needed it. No books were yet written to guide him ; the locomotive-engine was a new thing, railroads were yet young. His mind grew with the progress of the art, and he did his full share in that progress. Had he continued to the end of his life at the same work he would have still grown with his work, and would doubtless have still been a master-mind in that direction. But it must be remembered that the work he did and that others have done in advancing the mechanic arts, makes now more learning needed on the part of one who would take up engineering as a science at the place where he and they left off.

Towards the close of his life, Mr. Harrison turned his attention towards recording some of his thoughts and experiences. After writing some verses, entitled "The Iron Worker and King Solomon," intended for the amusement and instruction of his children, and designed to impress their minds with the "value of what is but too frequently thought to be very humble labor," he published a folio volume of over two hundred pages, containing this poem and some fugitive pieces accompanied by his autobiography, and many interesting incidents of life in Russia, also all the leading particulars of the invention of his boiler. He wrote a paper on the part taken by Philadelphians in the invention of the locomotive, an account of the completion and opening of the bridge over the Neva in

Russia, and a paper on steam boilers. In all these he showed considerable literary ability and fully sustained his claims to the possibility of self-education.

The dignity of labor was a favorite theme with him, and he held in high esteem the producers in the world's economy. He said that when he returned to America he found that undue prominence was given in society to mercantile pursuits and an underrating of mechanical occupations. During the year 1859, he gave a dinner party to fifty gentlemen, who were invited ostensibly to hear a lecture by Dr. Hays on the Open Polar Sea, but planned in reality to bring together certain persons in different positions in life who were representatives of different classes, and who were not well-known to each other. This object was fully explained by him to the writer, and was much dwelt upon in his mind at that time. He said that banking facilities were extended to merchants what were not accorded to mechanics; that in his early career he had felt this want of confidence very keenly, and he earnestly desired to help place the producer in his proper place in the opinion of the world as to usefulness. He lived to see a great change in this respect due somewhat to his own exertions, but may be more to the enforced need of exactness of mercantile pursuits in the conduct of the business of the manufacturer.

His interest in the fine arts was continued up to the close of his life, and it was known that he desired to give to his valuable collection some permanency, but pain and suffering came upon him too soon and thus suddenly checked much of his exertions. Only those who were near to him knew how much he suffered during the last few years of his life, and with what patience he bore a malady which he was conscious might at any time end his life in pain and suffering, and of which he yet hoped he might be cured. It is probable that his malady seriously affected him as early as 1869, for a letter dated August 12th of that year, addressed to him at Saratoga by his physician, says in speaking of the cause of his decease: "I have seen many cases of it in my life and they have all finally thrown the disorder off." This, however, was not to be in his case, and the best medical skill of the land only gave him partial relief, and five years of great suffering were only ended by the hand of death.

These years of illness did not prevent him from taking a great interest in all that was going on in the world of art and science, and he busied himself much in writing. He had lived to see his children grown up and settled. He leaves behind him a widow and six children—William, Henry and Annie, who was born in this country before he went to Russia; Alice M'Neil, Marie Olga and Theodore Leland, born in Russia, and Clara Elizabeth, born in America after their return. In his home life he was an affectionate husband, a kind and indulgent father, and at all times a dutiful son. The words written by himself to his family are full of love and kindness. His book for their use and comfort was dedicated:

"To Thee

Who Hast Been

For More Than Half My Life

My Truest Friend,

My Counselor,

My Wife."

During the latter part of his life he was connected with the Protestant Episcopal Church,* and had been a regular attendant at Divine service at all times. He made no outward show of religious bias, but ever bore himself as an honest, upright citizen striving to do what was right. His worth and ability led to his being asked to fill many positions of honor and trust, and he received many substantial evidences of appreciation of his work. For what he had done in the direction of safety in steam-boiler construction he was, on May 30, 1871, made the recipient of the great gold and silver Rumford medals by the American Academy of Arts and Science "for the mode of constructing steam boilers invented and perfected by" (Mr. Harrison), which "secures great safety in the use of high-pressure steam, and is, therefore, an important improvement in the application of heat."

Mr. Harrison was elected a member of this Association July 15, 1864; signed the Constitution and was introduced to the presiding officer, Judge Sharswood, Vice-President, December 2d, 1864, having accepted his membership by letter dated September 26, 1864. He was also a member of other learned societies, but with the exception of few papers read by him he did not take a very active part in the business of any of them. Of him it cannot be said that fortune was more kind than to others. His success was the legitimate outgrowth of his beginning. There may be some who "when they have planted their feet on the first rung of a ladder must needs mount;" with some the ladder of life is an unbroken one and to fall in climbing can be but from sheer carelessness. But his life was not without many trials. There were many missing rungs in that ladder, and these gaps, sometimes very wide, had to be crossed with prudent care. To him was intrusted the keeping of many talents, and he proved himself a good and faithful steward.

* Mr. Harrison was confirmed by Rt. Rev. Wm. Bacon Stevens, at the Church of the Holy Trinity (Nineteenth and Walnut streets), Sunday, May 2d, 1869. Rev. Phillips Brooks, Rector.

AN OBITUARY NOTICE OF CHARLES B. TREGO.

By Solomon W. Roberts.

(*Read before the American Philosophical Society, Feb.* 19, 1875.)

Charles B. Trego was born near Newtown, Bucks County, Pennsylvania, November 25th, 1794.

His ancesters were French Huguenots, who emigrated to England and, some of the family having become members of the Society of Friends, came over to America in the time of William Penn and settled at Chester, on the Delaware, and afterwards removed to Bucks County.

His boyhood was passed on his father's farm, and he went to school in the neighborhood; but not liking the occupation of farming, and anxious to improve himself, he began when young to teach school, and at the same time to study German; which was the language commonly spoken by many of the farmers. His handwriting was remarkably regular and beautiful, and continued to be so even to old age.

About 1821 he removed to Philadelphia, and taught a school in the city, living for a time in the same house with a German teacher of languages, and adding to the study of German, that of French, Spanish, Latin, Greek and Hebrew.

He taught school until he was about forty years of age, and studied Geology, Mineralogy and Botany, making a special study of Geology.

Although much occupied in studying and teaching, he took a lively interest in public affairs. In 1835 a political change took place in Pennsylvania, and the party to which he belonged was successful, electing the Governor and controlling the Legislature; and Mr. Trego was elected a member of the House of Representatives from the City of Philadelphia. He was also re-elected in the following year.

Soon after his election he introduced and was mainly instrumental in having enacted into a law, the Act for the first Geological Survey of Pennsylvania. It is understood that the post of State Geologist was offered to him by Governor Ritner, and declined by Mr. Trego. Professor Henry D. Rogers, received the appointment, and began the survey in 1836. In 1837, Mr. Trego became an assistant of Professor Rogers, and he continued in the survey until 1841; when he was again elected to the Legislature, and was re-chosen, year after year, until 1847; when he declined a re-election, and was succeeded by the writer of this obituary notice.

Mr. Trego was an intelligent, careful, pains-taking and honest legislator, and a faithful servant of the City of Philadelphia and of his native State. His knowledge of the different parts of Pennsylvania, and the character of his culture, gave him broad views, and added to his influence with his fellow members, and to his usefulness as a member from the city; as in many cases members from the country show an unwilling-

ness to be influenced by those from the city, unless they find them to be familiar with the interior of the State.

There is no doubt that the degree of success that attended the first Geological Survey, was largely due to Mr. Trego's influence at Harrisburg.

In 1843 he prepared and published a work on the Geography of Pennsylvania, which is a book of nearly four hundred pages, containing a large amount of information concerning the State. In the preface he says that "in the course of his duties as Assistant State Geologist, during four years, and on various other occasions, the author has visited most parts of the State, and has thus enjoyed opportunities of acquiring much local information concerning the different subjects embraced in this work."

He also prepared a mass of materials with the view of writing the history of the City of Philadelphia, and it is to be regretted that he never completed it.

Mr. Trego was, for some time, Professor of Geology in the Scientific Department of the University of Pennsylvania, and delivered lectures upon it in that institution.

On the 20th of January, 1843, more than thirty years ago, four persons who had been active in the affairs of the Franklin Institute, were elected members of the American Philosophical Society. They were Charles B. Trego, Charles Ellet, Jr., Ellwood Morris and the writer of this notice, who is now the sole survivor of the four.

On the 7th of January, 1848, Mr. Trego was elected one of the Secretaries, and was soon after chosen Librarian; and on the 15th of August, 1851, he was elected Treasurer of the Society, which office he retained until his death, a period of more than twenty years; and he also continued until the close of his life to be one of the Secretaries.

On the 30th day of June, 1854, the corporate existence of the Districts, Boroughs and Townships of the County of Philadelphia ceased, and they were merged in one municipal corporation with the City of Philadelphia; and about that time Mr. Trego removed into what had been the District of Spring Garden, and at once identified himself with the political and other interests of that part of the consolidated city.

From 1856 to 1862 he was a member of the City Council, and for four years of that time he was President of the Common Council. His long Legislative experience had made him very familiar with the rules of order of representative bodies, and his uprightness and firmness fitted him to preside. In 1863, when about sixty-nine years of age, he retired entirely from public life.

From that time until shortly before his death, he devoted himself, during eleven years, very much to the business and to the interests of the American Philosophical Society; not only attending the meetings, but occupying himself, for much of his time during business hours, in the Library of the Society. Here he was fond of seeing his old friends, and of talking over curious incidents in the history of the City and State.

He died of the disease of the heart, on the 10th of November, 1874; at which time he was within fifteen days of being eighty years old. He was buried in the burial-ground attached to the Friends' Meeting House, at Wrightstown, Bucks County. His widow and one son constitute his surviving family.

A number of the facts contained in this brief biographical notice, have been communicated to the writer by Mr. Trego's son, Mr. F. A. Trego, who has sought among his father's papers since his death, for his private journal, but has not been able to find it.

In looking back over the life of Mr. Trego, we see that while it was not distinguished by any very remarkable incidents, he has left behind him a good record.

He maintained the good reputation of the race from which he was descended; and living to the age of nearly four score years, he was useful to the end of his career, and as the faithful Treasurer of the American Philosophical Society, and the collector and disburser of its funds for nearly a quarter of a century, his memory well deserves to be honored by the members of the Society, as that of a good citizen, a lover of science, and a faithful steward of the talents with which he was intrusted.

ANALYSES OF ROCKY MOUNTAIN COAL.

By J. Blodget Britton and C. M. Cresson.

(*Read at a Meeting of the American Philosophical Society, Nov. 6, 1874.*)

The four coals from east of the Rocky Mountains and on the line of the Union Pacific Railroad, exhibited at the meeting held on the 6th ult., I have since analyzed for metallurgical purposes, with the following results:

Carbon Coal, from the Mine at Carbon.

(*Sample consisted of several pieces, and weighed* 12 lbs.)

Water	12.50
Volatile combustible matter	35.47
Fixed carbon	44.96
Ash	7.07
	100.00

One hundred parts of the raw coal gave of coke..... 52.03

The coke was composed of

Carbon	86.42
Ash	13.58
	100.00

Including sulphur 1.03
Phosphorus.....trace

Coal from Alury Mine.

(*Sample consisted of several pieces and fine stuff, and weighed* 21½ lbs.)

Water	12.95
Volatile combustible matter	32.54
Fixed carbon	44.56
Ash	9.95
	100.00

One hundred parts of the raw coal gave of coke..... 54.51

The coke was composed of

Carbon	81.75	
Ash	18.75	
	100.00	Including sulphur .29
		Phosphorus..... .04

Coal No. 3, from Mine at Rock Spring.

(*Sample consisted of a single piece, and weighed* 18½ lbs.)

Water	13.40
Volatile combustible matter	35.25
Fixed carbon	49.81
Ash	1.54
	100.00

One hundred parts of the raw coal gave of coke..... 51.35

The coke was composed of

Carbon	97.01	
Ash	2.99	
	100.00	Including sulphur .63
		Phosphorus..... .02

Coal from Excelsior Mine, at Rock Spring.

(*Sample consisted of several pieces and fine stuff, and weighed* 16½ lbs.)

Water	10.10
Volatile combustible matter	36.76
Fixed carbon	51.03
Ash	2.11
	100.00

One hundred parts of the raw coal gave of Coke..... 53.14

The coke was composed of

Carbon	96.03	
Ash	3.97	
	100.00	Including sulphur .92
		Phosphorus..... trace

The coals swelled very little during the coking. When powdered and heated they agglutinated. The cokes resemble in appearance the kind produced from the average bituminous coals of Western Pennsylvania.

A portion of the sample from Carbon Mine was subjected for an hour and a half to a temperature of 178° F., and lost in weight 5.72; subjected for one hour more to a temperature of 280° F., the loss was increased to 7.31; and again for two hours more to the same temperature, the whole loss was found to be 7.55. Another portion of the same sample was then subjected for three hours to a temperature of 500° F., and the loss was 9.55. The watery vapor was condensed in a cold glass tube, the tube was carefully weighed and then the water was evaporated; the tube when cold was weighed again, and from the loss the weight of water was ascertained. The coal was then weighed, and its loss was found to correspond very nearly with the weight of the water. A portion of the same coal was immediately put into another tube and subjected for a moment to a low red heat, when more water passed off and collected in the cold part of the tube; subjected for another moment to a little higher temperature, a dark brown oil passed off and condensed on the top, and ran down the sides of the tube in the space between the coal and water. The oil emitted a strong odor, the same as the oils produced by distillation from the brown friable lignites of Southern Arkansas and Texas. The other three coals produced water and oil in like manner at a low red heat.

These coals are not lignites, and I believe that if dried at a temperature of about 500° F., or a little above, will answer for puddling iron and the purposes of the blacksmith, and that the cokes will answer for producing pig iron in the blast furnace.

J. BLODGET BRITTON,
Iron Masters' Laboratory.

They were examined for steam and illuminating gas purposes by Dr. C. M. Cresson. The following is his report:

OFFICE AND LABORATORY,
No. 417 Walnut Street, Philadelphia.

Coals marked "Carbon Mine," "Excelsior," "Mine No. 3" and "Alury," have been examined as to their fitness for the production of steam, and suitability for producing illuminating gas, Pittsburgh (Pennsylvania Gas Coal) being used as the standard of comparison.

The following results have been obtained:

Coal.	*Pounds of Water evaporated by one pound of Coal.*	*Gas to the Pound of Coal when all of the Gas is worked off.*	*Value of Five Cubic Feet of Gas in Candles when all of the Gas is worked off.*	*Value of Five Cubic Ft. when the amount is limited to 4.4 Cubic Feet per Pound of Coal.*
Carbon Mine.....	13.42	5.17 Cu. Ft.	9.52	10.30
Excelsior.....	13.53	5.54 " "	11.80	12.00
Mine No. 3.....	12.65	6.06 " "	7.80	12.30
Alury.....	12.77	5.77 " "	6.90	9.
Penn. Gas Coal....	14.67	5.2 " "	12.	14.

The heating power of these coals compares favorably with that had from the majority of semi-bituminous and many bituminous coals. They should be burned in boilers adapted for use with bituminous coals.

As gas coals, Excelsior and Mine No. 3 possess fair qualities. They yield a very large amount of gas, and with a little enrichment (either by the admixture of cannel or a small amount of oils) will prove serviceable to the gas-maker.

If these samples are from outcrop or from near the surface, it will most likely be found that the quality of the coal will improve, as it is obtained from a greater depth; so that without any limitation in the quantity of gas yielded, they will compare more favorably with the eastern bituminous coals for gas purposes. Respectfully,

CHARLES M. CRESSON, M. D.

SYNOPSIS OF THE VERTEBRATA OF THE MIOCENE OF CUMBERLAND COUNTY, NEW JERSEY.

By E. D. Cope.

(*Read before the American Philosophical Society, Feb.* 5, 1875.)

The marls of the Miocene period appear in a limited area in Southwestern New Jersey, chiefly in Cumberland County. Their mineral character is similar to that of the marls of the same age in the Southern Atlantic States, viz.: a calcareous clay containing small percentages of phosphate of lime and potash. In New Jersey its strata abound in shells, and Vertebrate remains are rather common. Timothy A. Conard, the father of our Marine Tertiary Geology, as early as 1832, in his "Fossil Shells of the Tertiary," called it the upper marine formation, and stated that it "first appears in New Jersey, southeast of Salem, and continues throughout all the States south of this." Professor Rogers, in his Geology of New Jersey, published in 1840, p. 293, calls the beds Tertiary, and remarks "though this proposition (of shells) might rather imply an Eocene date for the deposit .... while on the other hand all the species are either identical with those of the Miocene of Maryland and Virginia, or exhibit a close analogy of form." In a memoir read before the American Philosophical Society, and published in the volume of Transactions for 1837, p. 334 Prof. Rogers, assigns the corresponding beds in Eastern Virginia to the Miocene period. The evidence derived from the vertebrate fossils does not conflict with this view. A full account of the geology of the formation as it appears in New Jersey, is given by Prof. G. H. Cook, in his report of the Geological Survey of New Jersey, 1868.

ELASMOBRANCHII.

LAMNA ELEGANS.

LAMNA CUSPIDATA.

LAMNA DENTICULATA.

OXYRHINA XIPHODON.

OXYRHINA MINUTA.

OTODUS APPENDICULATUS.

CARCHARODON MEGALODON.

CARCHARODON ANGUSTIDENS.

HEMIPRISTIS SERRA.

ZYGAENA PRISCA.

GALEOCERDO ADUNCUS.

GALEOCERDO EGERTONII.

NOTIDANUS PRIMIGENIUS.

AETOBATIS SP.

MYLIOBATIS SP.

ZYGOBATIS SP.

PLINTHICUS STENODON, Cope, Proceed. Boston Soc. Nat. History, 1867, p. 316.

PRISTIS AMBLODON, Cope, ibidem, 312.

ACTINOTERI.

PHYLLODUS CURVIDENS, Marsh, Proceed. Amer. Assoc. Adv. Science, 1870, p. 229.

CROMMYODUS IRREGULARIS, Cope, Proceed. Amer. Philos. Society, 1869, p. 243; Proceed. Boston Soc. Nat. History, 1869, p. 311.

PHASGANODUS GENTRYI, Cope, sp. nov.

Represented by one of the long teeth of the anterior part of the jaws. It is slender and curved backward, and the anterior view presents a cutting edge fron the apex to the base; there is no cutting edge nor angle on the posterior face, unless it be at the apex, which is broken off in the specimen. On one side the cementum is smooth; on the other, and posteriorly, the crown is keeled-striate from the base to near the apex. Length preserved, .010; long diameter at base, .0022; do. near apex, .0020; short diameter at base, .0012. Dedicated to my friend Thomas C. Gentry, of Philadelphia, an acute observer of nature.

SPYRAENODUS SPECIOSUS, Leidy, *Sphyraena speciosa*, Leidy, Proceed. Acad. Nat. Sciences, 1856, p. 221.

SPHYRAENODUS SILOVIANUS, Cope, sp. nov.

Represented principally by a portion of the dentary bone, supporting five teeth, and containing alveoli for four others. The jaw is compressed and slightly curved and with smooth surface. The teeth are subequal, compressed, rather short and acute, and without roots; at their bases the alveolar borders are notched. Length of fragment, .020; depth at middle, .004; length of a tooth, .003; long diameter at base, .002.

REPTILIA.

TRIONYX LIMA, Cope, Ext. Batr. Rept. N. Amer., 1870, p. 153. Pl. vii. Fig. 14.

PUPPIGERUS GRANDÆVUS, Leidy, *Chelone grandæva*, Leidy, Proceed. Acad. Philadelphia, 1861, p. 203; *Puppigerus grandævus*, Cope, Ext. Baltr. Rept. N. A., 1870, p. 235.

THECACHAMPSA SERICODON, Cope, Proceed Acad. Phila., 1867, p. 143; Ext. Batr. Rept. N. Amer., 1870, p. 43, Pl. v. Fig. 8.

INCERTAE SEDIS.

AGABELUS PORCATUS, Cope, gen. et sp. nov.

Established on an osseous body which nearly resembles the elongate muzzle of a *Priscodelphinus* without teeth, but with the alveolar lines excavated into a deep groove on each side. The superior surface possesses a shallow median groove as in most delphinoid cetaceans, while the supposed palatal face is plane and sharply defined by the lateral grooves. The latter are bounded above by a thin overhanging border on each side, and their fundus is marked by a series of nutritious foramena of small size, apparently corresponding to the positions of teeth of other genera.

With this imperfect material it is impossible to decide positively on the character of this genus, but I suspect that it will be found to be allied to the sword-dolphins of the genus *Rhabdosteus*, Cope.

Char. Specif. The general form is depressed, and the outline tapers regularly to near the apex. The upper face presents two convexities, one on each side of the median groove, but towards the base these parts are not exactly symmetrical. There is a narrow bevel descending to the margin on each side. The grooves are wide and deep, anteriorly wider than the palatal rib which separates them, and opening outward as well as downwards. Bone modera'ely dense, surface not covered with the cementum and faintly longitudinally line-grooved. Total length of fragment, M. .065; width do. at base, transversely .012, vertically, .006; with palate at base .007; at broken extremity, .002; depth at do. .0035.

MAMMALIA.

SQUALODON ATLANTICUS, Leidy, Cope, Proceed. Academy, Philada., 1867, p. 153; *Macrophoca atlantica*, Leidy, *l. c.* 1856, p. 220.

ZARHACHIS VELOX, Cope, Proceed. Acad. Philadelphia, 1869 (March).

PRISCODELPHINUS HARLANI, Leidy, Proceed. Acad. Phila., 1851, p. 327.

PRISCODELPHINUS LACERTOSUS, Cope, *Delphinapterus lacertosus*, Cope, ibidem, 1868, p. 190.

PRISCODELPHINUS GRANDÆVUS, Leidy, ibidem, 1851, p. 327. *Tretosphys grandævus*, Cope, ibidem, 1869 (March).

PRISCODELPHINUS URAEUS, Cope, *Tretosphys uraeus*, Cope, 1869 (March).

The four preceding species may be regarded as congeneric for the present, as they are similar in the forms of the vertebræ, especially in

the lumbar diapophyses. A few years ago I defined a genus, based on several species from the Miocene of Maryland, in which the lumbar diapophyses are spiniform. Supposing the *Priscodelphinus harlani* of Leidy to possess the same character I retained the same generic name for the Maryland species. After an examination of considerable material from the New Jersey locality, including bones of *P. harlanii*, I have failed to observe a single species with the spinous processes alluded to. It thus becomes evident that *Priscodelphinus* must be retained for the species termed by me *Tretosphys*, while that for which I retained the name *Priscodelphinus* must receive a new one. For this I propose *Belosphys* with *B. spinosus*, Cope, as type, and *B. atropius*, *B. conradi* and *B. stenus* as species. At the same time I add that the presence of *Ixacanthus coelospondylus*, Cope, in the New Jersey Miocene mentioned in Cook's Geological Survey of New Jersey by the writer, is doubtful.

Total number of species, thirty-three.

ORIGIN OF THE LOWER SILURIAN LIMONITES OF YORK AND ADAMS COUNTIES.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, March* 19, 1875.)

The three great deposits of Lower Silurian limestone which occur in this State, are: 1st. That of the Chester Valley which begins at Willow Grove, in Montgomery county, and terminates about a mile west of Minerstown, in Lancaster county; 2d. The great Lancaster and York county basin which, commencing about a mile northeast of Morgantown, crosses the Susquehanna River in two prongs, the longer (most northerly) of which terminates almost on Mason and Dixon's line in the southeast corner of Adams county; and 3d. The great valley, *par excellence*, which enters the State at Easton on the Delaware River, and passes into Maryland in a wide belt, which stretches fifteen miles east and the same distance west of Middleburg, Franklin county.

Accompanying all these limestone basins are belts of iron ore which crop out at tolerably uniform distances below their edges. In the still lower measures of the Silurian, and above the Potsdam sandstone, are other belts of ore entirely disconnected from the limestone ores.

In the first Report of the Geology of Pennsylvania (Vol. I, p. 218), it is stated of the Rathfon Ore Banks of Lancaster county, that in this, as in most of the other iron veins connected with the magnesian limestones,

the position of the ore is precisely at the junction of the limestone and slate. "It is indeed only a very ferruginous variety of the metamorphosed slate regularly stratified and intercalated with it."

Again, "west of the Gantner Ore Diggings," * * "the ore lies in decomposed sandy talco-micaceous slate between the sandstone and an outcrop of limestone south of it." And just beyond, "The Conewango Ore Bank lies at the junction of the Auroral limestone and the talco-micaceous slates of the primal series." In another place, the section of this limestone at Strickler's Run is given, commencing at the lowest number of the series:

1. Limestone, 150 feet.
2. Blue talcoid slate, 200 feet.
3. Limestone, 15 feet.
4. Dark-blue slate, 20 feet.
5. Limestone (?).
6. Bluish talcoid slate, 200 feet.
7. Limestone (?).

(Total 405 + feet).

Of the iron ores of York county, it is stated simply that a belt is traceable along the southern edge of the limestone towards Littlestown, but has been long neglected, owing probably to its containing a considerable portion of the oxide of manganese. All these statements agree in placing the limonites just beneath the Auroral limestone. The older ores seem not to be mentioned at all.

The ores of York county are of three kinds: 1st, pyritiferous and partly magnetic limonites; 2d, the limonites proper, which were the special objects of my investigation last summer; and 3d, the micaceous and magnetic ores of the Mesozoic sandstone. The first fact of importance with regard to the second of these kinds, is that (corroborated by Prof. Prime), they never occur far from the Auroral limestone, but always on its edges, thus skirting the entire basin (when not overlain by the Red Sandstone), and forming a line of ore wherever, within the limits of the basin, from folding and subsequent denudation, an edge of this Auroral limestone is exposed. 2d. They are *almost* always in the form of segregations in yellowish and bluish clay. 3d. Not only is each belt of ore made up of small pockets and nests lying without regularity in the decomposed slates constituting the clay, but in some cases the belt itself is capricious and appears to run out whenever the rock becomes less easily decomposable.

I should hesitate to ascribe the source of this iron supply to the minute crystals of pyrite which undoubtedly permeate some horizons of the great Calcareous deposit, both because their number and the porousness of the limestone as observed in connection with the ore,

seem to bear no relation to the latter. Besides, the supply of iron from such minute crystals in the limestone would be insufficient to produce the limonite beds. It seems much more probable that the source of the supply of iron were the pyrite crystals of the slates which, once towering high in the air, have been carried down by denudation and deposited in the Atlantic. Even these slates which are not so situated as to permit the percolation of water through them, exhibit a porous structure, the pores being filled with brown ochreous limonite, and this occurs to a considerable depth, and the slate merges by imperceptible degrees in a direction normal to the plane of bedding, first into completely metasomatized pseudomorphs of limonite after pyrite (but still retaining the form of the latter); then the same with a kernel of pyrite; then the pyrite itself, first with a shell and then with a mere stain of ferric hydrate; and finally the same slates are revealed porphyritic from the pyrite, but not at all decomposed.

The question as to the source of the iron in these limonite beds, is this: Does it come from the percolation and solution of its pyrite disseminated through the more recent limestone, or does it come from the decomposed pyrite in the slates of the same age? For it will hardly be disputed, that the main source of the supply consisted of pyrite, nor that the decomposition of the slates into clays was the means of providing the impermeable medium in which the iron solutions were caught and imprisoned. If the former hypothesis be the true one, we should expect to see an absence of limestone in the vicinity of the large deposits; for (granting for the moment that the limestone contains enough pyrites to account for the entire deposit (a fact which at least admits of some question), a percolation of water sufficient to oxidize the sulpbur of these pyrite crystals and carry away enough iron to produce the beds, would entirely honey-comb and finally, both by solution and attrition, dissipate the limestone bed. But in and near some of the largest limonite beds we find the limestone scarcely weathered, and in few cases, if any, is it rendered ferruginous or even stained to any great degree by chalybeate waters. Indeed, the absence of the familiar iron stain from the calcareous member of this formation is so marked, that this point of difference from the adjacent members of the series cannot fail to arrest attention.

Again the uniformity of the occurrence of these limonite deposits on the skirts of the basin and the lower edge of the elevated limestones and their absence elsewhere, cannot but be the result of the law of their formation. Were these deposits derived from the pyrite disseminated through the limestone there would be no way of explaining the adherence to the rule when the strata were highly inclined or vertical, except by supposing that the ferruginous solution from the limestone found its way across the decomposing slate beds in a direction perpendicular to their planes of lamination—an hypothesis opposed to all experience. But this would not account for the absence of iron oxide on the remaining edges of the limestone itself, for even if we could accept the

flow of the waters through the bedding we should be at a loss to account for the absence of that flow along the planes of bedding. It is objected in short to the hypothesis which would derive the limonite beds from the disseminated pyrite in the overlying limestone. 1st. That the less the limestone actually *overlies*, cæteris paribus, the greater the extent of the limonite deposits. 2d. There is no appearance of wasting in the limestone commensurate with the effect produced, and not even the staining from chalybeate waters which must have accompanied such a genesis. 3d. Very similar deposits are found in regions widely remote from the limestone (thousands of feet of measures below it,—*i. e.*, Hofacker's, and the Cameron Iron Co.'s mine, &c.).

The facts which are most intractable according to the former hypothesis might have been predicted on the latter. A large portion of the slates underlying the Auroral limestones are pyritiferous. A specimen taken from a point on the Peach Bottom Railroad, about five miles southeast of York was selected rather than one nearer to the limestone basin, because in these latter the pyrite is distributed in crystals too minute to be easily counted, while probably not differing materially in the amount of iron contained. A slab of this slate $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ inches was examined to ascertain the number of prints of pyrite crystals which it contained. On the area of the surface $3\frac{1}{2} \times 2\frac{1}{2} = 8.75$ sq. inches there were counted 350 such pits visible to the naked eye.

A micrometric measurement of a large number of these pits gave all intermediate dimensions between $\frac{1}{16}$ and $\frac{1}{48}$ of an inch. Assuming the mean of the cubes of these dimensions or 0.000213 cubic inch as the average size of a crystal, we have 40 such crystals in 1 square inch, occupying 0.00851 cubic inch. In the specimen examined which was $\frac{3}{8}$ inch thick, there were nine layers distinctly visible to the naked eye. Each layer was therefore $\frac{1}{24}$ inch in thickness, and supposing only 0.00852 cubic inch of pyrite in each square inch of laminæ, we have $0.00852 \times 24 \times 12 \times 5 = 12.27$ cubic inches of pyrite in every square inch of area and 5 feet of thickness of these slates. One cubic inch of pyrite weighs 126.1 grains. In the above thickness and area of these slates there are then 1547.25 grains, or in each square foot of the same thickness 222803.57 grains = 31.81 lbs.

This would give us for every mile of outcrop and 1000 feet of arch above the present surface the enormous sum of 168,009,600 lbs. = 75,004 tons of 2240 lbs. But the metallic iron in this mass of slates one mile in length and five feet in thickness would weigh 47729.7 tons, and supposing it to be also oxidized, the anhydrous oxide would weigh 68185.2 tons and as limonite 79691.5 tons.

Assuming $\frac{1}{4}$ of this to be washed into the soil and $\frac{3}{4}$ to be left as earthy iron ochre in the pits originally filled by pyrite in the slates still in place and only partially decomposed,—which lie in juxtaposition to the ore; then every outcrop of these slates one mile long and *one foot* deep has contributed about 20 tons to the deposits. But the entire mass of the rocks

which were formerly above the present surface have been washed away, and with them their 47,730 tons of metallic iron, or their 79,691 tons of limonite (if all this iron was hydroxidized), for every 1000 feet of slope, 5 feet of thickness and 1 mile of outcrop. Added to the smaller contribution of the partially weathered slates at the surface, this gives the total of 79,711 tons of limonite per mile, which has been gradually carried down the dip and segregated among the clays. But these slates are of very great thickness—at least 100 times what has been assumed. Allowing, then, for all loss by transportation into the sea, and through breaks in the continuity of the clay beds to great depths under ground, and for combination with the silicates to form double salts, we still have more than enough to account for all the largest ore banks. It will be asked, why these deposits should bear so close a geographical relation to the limestone basins? An example taken from Feigley & Brillhart's bank in the Dunkard Valley, one mile east of Logansville, is interesting in this connection. Here is the southwest limit of the easterly portion of the small limestone trough which runs parallel with and south of the greater York county synclinal. About a quarter of a mile east of Brillhart's works there occurs a rock almost indistinguishable from the other slates but which contains ± 33 per cent. (?) of calcium carbonate.

This indicates either that these slates have been subjected to a long soaking with calcium bicarbonate or that the deposits of the carbonate of lime proceeded together with the mechanical deposition of the sediments which formed the slate bed.

In reference to the older limonite formations of Lancaster county, it is said (Vol. I, p. 183): "An interesting inquiry is here suggested as to what can have been the geological atmospheric condition which produced the remarkable percolation which carried down so large an amount of ore out of these ferruginous beds. Was it tepid rain charged with carbonic acid in an early Palæozoic period? Or could it have been a long filtration of surface waters such as now soak the earth? Or are we to surmise an action of internal steam issuing upwards through crevices in the strata in a period of crust movement and disturbance? I am inclined to the first conjecture."

Dr. Hunt in his essay on metalliferous deposits (XII, Chem. and Geol. Essays, Boston, 1875, p. 229), says: "The question has been asked me—Where are the evidences of the organic material which was required to produce the vast beds of iron ore found in the ancient crystalline rocks? I answer that the organic matter was in most cases entirely consumed in producing these great results, and that it was the large proportion of iron diffused in the soils and waters of those early times which not only rendered possible the accumulation of such great beds of ore, but oxidized and destroyed the organic matter, which in later ages appear in coals, lignites, pyroschists and bitumens. Some of the carbon * * is, however, still preserved in the form of graphite," &c.

With reference to the Ferric Sulphide or pyrite, the same author

ascribes its formation to the deoxidizing agency of decaying organic matters out of contact with air on soluble sulphate of lime and magnesia, giving rise, if carbonic acid be present, to Hydrogen Sulphide which "in some conditions not well understood contains two equivalents of sulphur to one of iron." He adds that he has observed that the ferrous sulphide or proto-sulphide of iron in presence of a per-salt of iron loses one-half of its iron, the rest being converted to Ferric Sulphide."

It seems at least a possible explanation for this more prominent determination of limonite along the edge of limestone, that by the oxidation of the pyrites of the slates an equivalent of sulphuric acid in addition to that necessary to form Ferric Sulphate has been produced. That this molecule of free sulphuric acid in its passage over the mica and chlorite slates has dissolved out part of their alkalies, especially soda. That this solution of sodium sulphate has mingled in the clay beds below with the solution of calcium bicarbonate, produced by the drainage of rain waters over the limestone beds, giving rise to sodium bicarbonate and calcium sulphate. That this sodium bicarbonate reacting on the Ferrous Sulphate has precipitated Hydro-Ferrous Carbonate which has been by oxidation rapidly converted to Ferric Hydrate, while the Ferric Sulphate has been immediately thrown down as hydrous oxide. This, be it repeated, is simply one of many explanations which may suggest themselves of the observed fact that the limonite deposits are more frequent and extensive in the neighborhood of limestone deposits.

But though the solutions from such basins may favor the deposition of this ore, they are not always necessary.

It has been incidentally stated that one proof that the supposed iron in limestones was not necessary for the formation of these limonite beds, is that very similar limonite beds are known to occur miles away from any known outcrop of limestone. Such are the beds referred to as the Hofacker, Cameron Co., Keeny Banks, &c., &c., which occur in the lower part of York county and the upper portion of Baltimore and Carroll counties, Maryland. The circumstances of occurrence alike in both cases are the pyritiferous character and the highly inclined strata. The former is much more coarsely porphyritic in the older beds so that the hydroxidation of the pyrites has not been so perfect, and the ore is much more red short than is the case close to the limestone. But the large amount of pyrites in the rocks, in all stages of transition to limonite, would seem to render the search for any other source of supply of iron unnecessary.

NOTES ON THE GEOLOGY OF WEST VIRGINIA.

No. II. *

By Jno. J. Stevenson.

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(*Read before the American Philosophical Society, February 5th*, 1875.)

During July and part of August, 1874, I made a reconnaissance of a portion of West Virginia lying between Rich Mountain and the Ohio River. In this area are included parts of Randolph, Upshur, Harrison, Lewis, Doddridge, Ritchie and Wood counties. To connect this work with that reported in my previous paper, I made some examinations in Taylor and Marion counties.

This whole region has suffered much from erosion, and its surface is a confused mass of hills and ravines apparently without system. In the eastern portion, that drained by the forks of the Monongahela River, the valleys are usually quite broad and the hills are rounded except in the vicinity of Rich Mountain, where, owing to the increasing dip, the slopes become quite sharp. In this drainage area the main streams flow across the dip, whence result the broad valleys and gentle slopes observed on Tygarts, Buckhannon, and the West Fork River. On the west side of the divide, separating the Monongahela from Hughes' River on the Little Kanawha, the conditions are different. There the streams flow, for the most part, with or opposed to the dip, so that one finds the country abrupt and the valleys narrow until he approaches the Ohio.

Between Rich Mountain and the Ohio the soil is not very rich, owing to the comparatively small quantity of limestone present. In portions of Randolph and Upshur counties, however, there is much rich land along the "bottoms," the alluvium being in a measure derived from the lower carboniferous rocks. The western portion of the area is very lean, as the soil has resulted simply from disintegration of the Upper Barren shales or sandstones, or in other localities from similar disintegration of the red argillaceous shales of the Lower Barron Group. It is said that in Doddridge, Ritchie and Wood counties, there is comparatively little land rich enough to yield forty bushels of corn per acre.

Over the greater portion of the area, the hills are covered by a dense growth of valuable timber, consisting chiefly of poplar (tulip-tree), red and other oaks, chestnut, beech and maple. The oak and poplar are quite valuable. At the west, much of this timber is floated to the Ohio by way of the Little Kanawha, not a little of it being sent down as single logs from the smaller tributaries. The magnificent timber on Rich Mountain will soon be available, as the obstructions in Buckhannon and Tygarts' Rivers are to be removed, so as to open the way to Grafton, where immense sawmills have been erected.

The availabilities of the country have not been fully tested, and for the

* No. I was published in Trans. A. P. S., Vol. XV, p. 15.

most part, it is thinly settled. Such of the inhabitants as have means, devote themselves to raising stock or wool, while the poorer classes are wasting their substance by cutting the fine timber into staves or shingles.

Throughout this whole region, evidences of drift are entirely wanting. The superficial deposits are thin except at the east, where the debris on the hills is so thick as to render satisfactory tracing of the strata almost impossible. Along the northwest Branch of the Baltimore and Ohio Railway, one finds frequent proof of the deepening of waterways, for on top of many hills, seventy-five to one hundred feet above the present streams, there occur fresh-water shells similar to those now living in the creeks.

Rich Mountain is the western slope of a great anticlinal ridge, whose eastern slope is known as Cheat Mountain. Between the two mountains is the anticlinal valley of Tygarts' River, whose scenery can hardly be excelled. Along the central line of this valley the dip of the strata is nearly 65° northwest and somewhat less southeast. Taking the Staunton pike westwardly, we find the dip diminishing, so that on top of Rich Mountain it is only 18°. Thence the decrease is very rapid, and at Roaring Creek the strata are almost horizontal. This condition continues for nearly twelve miles along the pike; after which the northwest dip is resumed, now 120 feet to the mile, and is retained until about two miles west from Buckhannon. There it is reversed, and we meet the anticlinal fold of Laurel Hill. The plane of this axis crosses the pike about three miles west from Weston, and there the dip is again toward the northwest at the rate of nearly 150 feet per mile. This rate continues for about twenty miles, beyond which the strata become almost horizontal. The Laurel Hill anticlinal crosses the railroad not far from Flemington, and the flattening of the strata begins near Long Run Station, thirty miles farther west.

About one-eighth of a mile east from Ellenboro' and forty-five miles west from Clarksburg, a sharp fault occurs, on whose eastern side the rocks dip almost due east at an angle of 26°, while on the western side the strata are horizontal. The exact line of fault is not exposed, and there is an interval of seventy feet concealed between the points of observation. The approximate horizontality continues westward to within a mile of Petroleum, where the dip becomes eastward and rapidly increases, followed west, until just west from that station it becomes 36°. From this point almost to Laurel Junction somewhat more than one mile, the dip is very confused, but a shattered anticlinal can be traced, the rocks meanwhile dipping east or west, as the case may be, at from one to five degrees. Near Laurel Junction the dip becomes five, ten, twenty, forty or even seventy-five degrees westward. In the cut immediately west from that station the rate decreases to five degrees within a space of six feet horizontally, and soon afterwards falls to only ten feet per mile. Beyond this to the Ohio the rocks remain almost horizontal.

The section obtained in passing from Rich Mountain to the Ohio embraces the whole of the Upper Carboniferous as found in West Virginia, and, if begun on the east slope of the mountain, includes also a very large portion of the Lower Carboniferous. The anticlinal valley of Tygarts' River is cut out of the Lower Carboniferous series, which is well exposed on each wall to the crests of the mountains. On top of Rich Mountain we find the Great Conglomerate forming the crest throughout Randolph county. On the western slope of the ridge are the Lower Coals, which pass under the surface before reaching the Buckhannon River in Upshur county. The Lower Barren Group is well exposed toward the foot of the mountain near Roaring Creek, and thence westward in the bluffs for nearly forty miles; but, owing to the flattening of the dip near Roaring Creek, it is the surface series for only a few miles in the area examined. Northward from the Baltimore and Ohio Railroad, or, better perhaps, at the State line, the Upper Coal Group finds its eastern outcrop several miles from Laurel Hill, but followed southward this outcrop is seen approaching the crest of the axis until near the railroad it crosses it. Along our southern line the fold becomes very gentle, so that the Pittsburg crosses its crest and has its outcrop nearly twenty-five miles east from it. The eastern boundary of the group is very tortuous. The Upper Coals extend westward almost to the line of the Ellenboro' fault, where the Lower Barren Group is thrust up. This continues to the especially disturbed area known as the "Oil-break," in which the Lower Coal Group is exposed. Beyond the "break" to the Ohio River the only rocks exposed are those of the Lower Barren. The region lying west from the Ellenboro' fault will be described separately.

The Upper Barren Group is cut off by the Ellenboro' fault, but eastward from that for nearly twenty miles its rocks are those covering the surface, those of the Upper Coal Group being found only in the deeper ravines.

The Coal Measures.

In this paper the terms, Upper Barren, Upper Coal, Lower Barren, and Lower Coal, as designations of the several groups into which the Coal Measures are naturally divided, are used in precisely the same sense as in my previous paper.

Upper Barren Group. This group, which includes all the rocks above the *Waynesburg Coal*, covers a large extent of territory, whose western line is the Ellenboro' fault. The eastern outcrop is an ill-defined line, passing a little west from Troy, in Gilmer county northward, and coinciding almost with the western line of Lewis county. It crosses the Northwestern Railroad near Wolfe's Summit, eight miles from Clarksburg, and running irregularly northeast, reaches the Baltimore and Ohio Railroad about three miles north from Fairmont, passing finally into Pennsylvania nearly four miles west from the Monongahela River.

The northwestern boundary in West Virginia is a line passing from the

Pennsylvania border near the junction of Ohio and Marshall counties, West Virginia, to a little below Moundsville, on the Ohio River. This is the overlying group in Doddridge, Tyler and Wetzel counties, as well as in the eastern half of Ritchie and the western portions of Monongalia, Marion, Harrison, Lewis and Gilmer counties.

The sudden cutting off of this group by the Ellenboro' fault and the consequent wearing away of the rocks by erosion prevent us from obtaining as full a section along this line as may be found farther north. The succession as observed here is as follows :

	Ft.	In.	
1. Sandstones and shales.....	400		
2. Black shale.....	2′		
3. *Coal* "Brownsville".....	3′		
4. Shale.....	20′		
5. Sandstone.....	5–15		Interval, 38 ft. to 28 ft.
6. Shale.....	3		
7. *Coal*.....		2	
8. Shale	20		Interval, 75 ft.
9. Sandstone and some shale....	55		

The total thickness of the group as here exposed is only five hundred and twenty feet. For comparison, I present a condensed form of the excellent section worked out by Mr. I. C. White,* in southwestern Pennsylvania and northwestern West Virginia :

	Ft.	In.	
1. Sandstones and shales,.....	300		
2. Limestone.....	1	6	491½ ft.
3. Sandstone.....	190		
4. *Coal*.....	1	6	
5. Sandstone.....	95		Interval, 95 ft.
6. *Coal*.....	2		
7. Shale and sandstone.....	85		
8. Limestone	3		Interval, 128 ft.
9. Shale.....	40		
10. *Coal*.....	1	4	
11. Shale.....	10		
12. Limestone	2		Interval, 52 ft.
13. Shale	40		
14. *Coal* "Brownsville"	2–3	6	
15. Shale.....	20		Interval, 20 ft.
16. *Coal*.....	1		
17. Shale.....	15		Interval, 60–65 ft.
18. Sandstone.....45–50			

In this section the total thickness is eight hundred and sixty feet. It

* Annals Lyceum of Nat. Hist., Vol. XI, p. 46.

will be seen, however, that in my section the strata reach far enough up to include a portion of No. 3, in Mr. White's section, so that sufficient is found in the south to afford material for comparison of conditions in the two areas. It is noteworthy that the interval between the *Waynesburg* and the *Brownsville* is much greater in the southern than the northern section.

No. 1 of the section is entirely free from limestone, and consists of compact sandstones and loose shales. At the east, the sandstones greatly preponderate, and are very coarse in grain. Westward they diminish in quantity and are replaced by the shales. These are reddish gray to yellow and usually quite fissile. The whole series is finely exposed along the Northwestern pike, about four miles west from Salem, where the road descends a long steep hill and is merely a shelf, cut out of these rocks. Near Cherry Camp, thirteen miles west from Clarksburg, the base of the series is a bright yellow fissile shale, twenty feet thick, containing many crushed specimens of an *aviculopecten*. This shale is not persistent, being wanting at all exposures examined farther to the west. The other strata seem to be entirely free from fossils.

Along the Northwestern Railroad, the *Brownsville** coal is first seen at the east end of Brandy Gap Tunnel, ten miles west from Clarksburg. There it was worked formerly, but the banks have been long deserted and no measurement can be made. At the west end of the tunnel the coal is seen about twenty feet above the track and nearly three feet thick, Near Cherry Camp, one mile beyond, it has been worked in the creek bank by stripping. It shows there

Shale, 2 ft.; *Coal*, 9 in.; Bony Coal, 5 in.; *Coal*, 14–16 in.; total, 2 ft. 6 in.

The shale is full of vegetable impressions, some of which are very fine. If this shale could be reached farther in the bank, where it has not been exposed to the action of the weather, the locality would no doubt yield some excellent material to the palæo-botanist. The coal is said to be of very fair quality. Some taken from the same bed where it lies exposed in the stream, about one-fourth of a mile farther west, is said to have been very good.

The next exposure was found on the Northwestern pike, somewhat more than five miles west from Salem. The bed is there more complex than at Cherry Camp, and shows the following section:

Coal, 9 in.; Shale, 2 ft.; Bituminous shale, 1 ft.; Clay, 3 in.; *Coal*, 1 ft. to 1 ft. 6 in.

The sandstone rests directly on the coal. The bituminous shale contains many thin plates of coal and is so carbonaceous throughout that it will burn, though poorly. The coal is said to be quite good, and is mined by stripping. Near the railroad crossing, two miles east from Smithton, this bed was formerly worked. At Smithton its outcrop is

* So named by Mr. White, from its importance, near Brownsville, Monongalia county, West Virginia.

seen one hundred and fifteen feet above the *Waynesburg*, and near West Union it was observed in a railroad cutting, where it appears to be about one foot thick and single.

Near Pennsboro' an old opening is seen twenty feet below the level of the railroad. We there find the following section:

Sandstone,—; Shale, 10 ft.; *Coal*, 1 ft. 10 in.; Compact clay, 3–6 in.; *Coal*, 8 in.

The overlying shale is argillaceous below, but becomes arenaceous above and passes gradually into sandstone. The rocks are well exposed in the vicinity for nearly two hundred and fifty feet above the bed and are wholly sandstone and arenaceous shale. The coal seems to be quite good and must contain very little pyrites. The bank has been deserted for nearly twenty years, yet fragments lying on the dump are as sound and fresh-looking as though they had been thrown out within two or three days. The same bed is mined somewhat on the other side of the railroad. The coal is compact, open-burning, and leaves a pulverulent ash, quite bulky but not heavy. The bed can be traced in the vicinity of the railroad almost to Ellenboro'. The blossom is seen near the junction of the Northwestern pike and the Harrisville road. Near Harrisville its place is shown by a line of springs. On the Staunton pike it was seen only near Smithville, in Ritchie county, where it is one foot thick.

The small coal, No. 7, was observed only in the deep cut at the east end of Brandy Gap tunnel.

The shale underlying the *Brownsville* coal is variable in character and thickness. Occasionally the whole mass for thirty-five feet is argillaceous, blue to gray or drab, and quite thinly laminated. At other times, the whole interval between the *Brownsville* and the *Waynesburg* is occupied by a coarse sandstone.

The Waynesburg sandstone, No. 9, is a well marked and very persistent member of the series. It is ordinarily a compact and fine-grained sandstone, and at no place along the railroad is it at all conglomerate. Near Brandy Gap tunnel, where it has been largely quarried by the railroad company, its lower portion is somewhat flaggy. At Long Run, Smithton and West Union, it stands out in cliffs upon the hill sides, and is compact throughout. On the Staunton pike, it may be seen just west from Troy, where it is somewhat coarser than at the localities just mentioned.

Upper Coal Group. Under this name are included all that series of rocks beginning with the *Pittsburg* and ending with the *Waynesburg* coal. Along the Northwestern Railroad the group is well exposed from Clarksburg west. The general section is approximately as follows:

	Ft.	In.	
1. *Waynesburg Coal*	4		
2. Shale	8′		
3. Limestone and shale	6		
4. Argillaceous shale	20		
5. Limestone	1	6	
6. Arenaceous shale	30		Interval, 132 ft.
7. Limestone and shale	7		
8. Variegated shale	8		
9. Dark shale	6		
10. Sandstone	40		
11. Shale	6		
12. *Sewickly Coal*	2–3		
13. Shale	41		Interval, 41 ft.
14. *Redstone Coal*	3–2		
15. Fire-clay	2		
16. Limestone and shale	8		Interval, 20 ft.
17. Shale	10		
18. *Pittsburg Coal*	6–9		

The interval between the *Waynesburg* and the *Sewickly* is very much smaller than in the northern portion of the State, where it varies from one hundred and seventy-five to two hundred feet, averaging about one hundred and eighty feet. Near Morgantown, this interval is one hundred and eighty, at Fairmont almost the same,* at Clarksburg one hundred and sixty, and ten miles west from Clarksburg, as given in the section above. The interval seems to decrease in this direction. Were this evidence absent, the character of the bed itself would leave no room for doubt respecting its identity with the *Waynesburg*.

No satisfactory exposures of this coal were observed except near the railroad. Its blossom is seen on the north side of the railroad near Clarksburg, at one hundred and sixty feet above the *Sewickly*. It is worked slightly at about nine miles west from Clarksburg, where it shows four feet of coal, divided nearly midway by a clay parting one foot thick. From this point westward, it was not seen until within two or three miles of Smithton, where there have been numerous openings, nearly all of them now deserted. At all of these, the bed is overlaid by twelve feet of dark argillaceous shale, containing vegetable impressions and holding midway, a layer of calcareous iron ore. At Smithton, the coal is worked by Mr. Smith, at whose bank the following structure is shown :

Shale, with vegetable impressions, 4 ft.; *Coal*, 2 ft. 2 in.; Clay, 3 in.; *Coal*, 2 in.; Cannel, 3 in.; Shale, dark-gray, fissile, 8 ft.; *Coal*, 1 ft. 6 in.

The coal is not very good, owing to the considerable proportion of sulphur. The bottom layer yields the best fuel, but as it is mined by strip-

* The Sewickly has not been seen at Fairmont, and this calculation is based on the relation of the Waynesburg to the Redstone.

ping in the run, the superiority may be owing entirely to removal of the pyrites by the water. The same bed is mined somewhat extensively at West Union, where one finds

Shale, 2 to 8 ft.; *Coal*, Cannel, 3 in.; Clay, 2 in.; *Coal*, 31 in.; Clay, 4–11 in.; *Coal*, 6 in.; Fire-clay, 3 ft.; Shale, to road, 7 ft.

The overlying shale is drab or slate-colored, quite fissile, and contains much nodular iron ore. It exhibits vast numbers of vegetable impressions, chiefly *Neuropteris*, *Cyclopteris*, *Pecopteris* and *Sphenophyllum*. Many of these are beautifully defined and equal those from the same horizon in Monongalia county. This shale varies in thickness at the expense of the sandstone above it. The fire-clay underlylng the coal passes gradually into ferruginous, slightly arenaceous shales, below which, some limestone is seen farther up the stream. The upper parting in the bed occasionally shows leaf-prints. The lower parting is variable in thickness, and sometimes holds two sheets of coal, each one inch thick. The main coal is very hard, evidently open-burning and bears much resemblance to semi-cannel. It is said to be an excellent fuel. Though showing but little pyrites, when freshly mined, it becomes streaked with copperas when exposed to the weather. In this vicinity the bed is cut by numerous vertical seams of drab clay, which are quite distinct in the solid coal.

Along the Staunton pike this bed is much degraded. Several openings have been made upon it between Smithville and Troy, but it nowhere exceeds two feet. At a short distance east from Harrisville, in Ritchie county, it is found varying from six to eighteen inches in thickness.

Northward from the railroad this coal steadily increases in thickness until near the State line it averages more than eight feet, varying from eight to eleven. It is rarely single, usually double, and frequently triple.

The rocks occupying the interval between the *Waynesburg* and the *Sewickly*, show variations which deserve some consideration. Near the State line on the Monongahela River we find here, fifty-six feet of limestone, and at Wheeling there is one mass of limestone and calcareous shale, fully one hundred feet thick. At both localities much of the limestone is compact and quite pure. Along the Northwestern pike and the railroad, not more than sixteen or twenty feet of limestone can be found, and most of this is so poor that it ought rather to be called a compact calcareous shale. Still farther south, along the Staunton and Parksburg pike, not one foot of limestone was observed in this interval. From the northern portion of the State to the railroad, the limestone diminishes and gives place to shale, but from that line southward the shale apparently disappears, and sandstones appear instead. Along the railroad the limestones were seen near Wolfe's Summit, near Smithton and West Union. Traces of them occur east from Harrisville.

The *Sewickly coal* was identified at only two localities. At Clarksburg,

it occurs two feet six inches thick, and seventy feet above the Pittsburg. No attempt has been made to ascertain its value. On Wolfe's Summit, eight miles west from Clarksburg, the coal is only two inches thick. This bed seems to have as little persistence as the coals of the Barren Group, when traced southwardly. It has not been found at Fairmont, in Marion county.* No traces of it occur along the Staunton pike, in Gilmer county, and I cannot speak with certainty respecting its presence in either Lewis or Upshur county. It is, however, by no means improbable that the small coal above the Pittsburg in the latter county, is the Sewickly, and not the Redstone.

The interval between the *Sewickly* and the *Redstone* is entirely free from limestone. It is occupied by shale, none of which is calcareous. At Wheeling this space is filled with limestone, and on the Monongahela River near the State line, it contains thirty-one feet of limestone. On the Staunton pike the shales are replaced by flaggy sandstones.

The *Redstone* is a wide-spread and persistent coal, though rarely of economical value in West Virginia. At Fairmont, in Marion county, it is three feet thick and of good quality, but is not mined. Between that town and Clarksburg, its blossom is frequently seen in the roadside, and at the latter place it is six inches thick at the outcrop. At Wilsonburg, four miles west from Clarksburg, it is barely one foot thick, while at Coketon, two miles beyond, it is four feet, and of excellent quality. Where last seen toward the west, at Wolfe's Summit, it is only three inches thick. A thin coal, varying from one to two feet, is found above the *Pittsburg* in Upshur county. Whether or not this is the Redstone, the material in my possession is not sufficient to decide.

The rocks occupying the interval between the *Redstone* and the *Pittsburg* are subject to great variations in character and thickness. At Fairmont the interval is eighty feet, at Pruntytown, seventy-five, at Bridgeport, sixty-five, and at Weston, somewhat less. At all of these localities which lie along a nearly northeast and southwest line, the interval is occupied by sandstone and shale at the base, and limestone on top. Westward from such a line passing through Morgantown, Fairmont, Bridgeport and Weston, the distance between the coals rapidly diminishes. At Clarksburg, it is twenty-five feet, occupied by shale or sandstone; at Wilsonburg, it is the same, filled with argillaceous shale; at Coketon, it is twenty-eight feet; while at Wolfe's Summit, it is twenty feet, the rocks being shale and limestone. A similar condition exists in the vicinity of Morgantown, as stated in my previous paper.

The limestone disappears altogether before reaching the Staunton pike, so that with the exception of a few scattered nodules no limestone occurs among the strata of this group along that line.

* In my previous paper, I stated that it occurred at Fairmont. I had misunderstood the statement made to me by Ex-Governor Pierpoint, respecting the coals of that vicinity.

Pittsburg Coal. The eastern limit of this bed aside from small outlying areas, is marked by a line beginning near Cheat River, on the Pennsylvania border, and extending west of south to Fairmont, and crossing the Tygarts' Valley River, a little above that town. Thence irregularly to Pruntytown, where it turns east by south to Flemington. From this point it follows a south-southeast course, almost to Tygarts' River, thence southward, crossing the Buckhannon River near the Upshur county line. There it again turns east by south, and so continues almost to the middle fork of that river, when the course changes to southwest, and so remains to the line between Upshur and Lewis counties. From this locality to where the bed crosses Pocatalico Creek near the Great Kanawha River, I have not followed it. The extreme eastern exposure occurs in Upshur county, about five miles east from Buckhannon, on the Staunton pike.

The extreme western line of exposure begins at the Pennsylvania line, nearly two miles west from Monongahela River, crosses that river about a mile below Fairmont. It lies a little west from the West Fork River, crossing Harrison county from Shinnston to Wolfe's Summit, on the Northwestern Railroad. Thence it runs southwestward through Lewis county, reaching Gilmer, near Troy, on the Staunton pike, and crossing the Little Kanawha, just below Glenville.

Owing to the abruptness of the Laurel Hill anticlinal, the area in which this bed is available is very narrow at the north, hardly more than six or seven miles wide. Southward the anticlinal becomes gentler and this area rapidly increases in width until along the Staunton pike the coal is available for a distance of nearly forty miles. The bed attains its greatest thickness toward the north, and diminishes toward the south and southeast.

In Monongalia county, this bed is double, except where overlaid by sandstone. This characteristic prevails in Pennsylvania and Ohio, as well as in the Ohio Panhandle of West Virginia. But southward from Fairmont this division is rarely marked by a distinct clay parting, though the difference between the upper and lower benches sufficiently proves that the bed is still double. Occasionally, however, as at Shinnston and near the tunnel east from Clarksburg a well-defined clay parting separates the two branches.

In Upsher county the openings are quite numerous in the vicinity of Buckhannon, and the *Pittsburg* is the only source of supply for a large area. The coal varies from three feet nine inches to four feet, and is said to be of very fair quality. Though the parting is exceedingly thin, the upper and the lower benches are very distinct, the former being hard and leaving a bulky red ash, the latter being soft and clean, yielding a white ash. In the northern part of the county, very near the Barbour county line, the coal is mined on the Westfall property, where it shows

Coal, 32 in ; Parting, $\frac{1}{8}$ in.; *Coal*, 34 in.; total, 5 ft. 6 in.

Though very thin, the parting is persistent. The upper bench is quite

hard and contains a good deal of bony semi-cannel, but the proportion of good clean coal is quite large. It burns well, but leaves a bulky ash. The lower bench is a remarkably clean coal. Layers of apparently pure bitumen are seen, two to four inches thick, structureless, showing no lamination, and breaking with beautifully conchoidal fracture. At this opening the coal is exceedingly good, and shows no pyrites under a glass. It does not disintegrate upon exposure, nor does it exhibit streaks of copperas. Near this opening is the Connolly bank. At the time when it was examined, this had not been fully opened, and only five feet of coal were exposed. The appearance is somewhat strange, as no division into benches can be made out, and the bed seems to be homogeneous. The coal is pure throughout, and evidently very rich in volatile combustible matter. The coal from these banks would yield an excellent coke, and would be exceedingly profitable in gas-making.

In Lewis county, this bed is easily accessible, and it is worked quite extensively to supply local demand. Openings were examined only along the Staunton road, though many were seen on the West Fork River, both above and below Weston. In the central portion of the county the thickness varies from four feet six inches to nearly eight feet, increasing northward. The bed is apparently single, but close examination shows the existence of two benches, the upper being invariably harder and less pure than the lower. Owing to the thinness of this bed in the southern portion of the county, many persons do not believe it to be the *Pittsburg*, but refer to that horizon the *Upper Freeport*, which appears to be quite thick in the river near Weston.

In Gilmer county the coal is mined near Glenville, where it is from four to five feet thick. About one mile east from Troy, an opening shows the following section :

Shale, gray, 8 ft.; *Coal*, 29 in.; Parting, ½ in.; *Coal*, 38 in.; total, 5 ft. 7½ in.

The coal is very good and shows but little pyrites. The upper bench is quite compact and leaves a red ash. The lower is softer and burns more readily, leaving a not bulky, white ash. About one-half mile farther east is a bank in which the coal is seven feet at the mouth, and farther in is said to reach nine feet. Near the county line the coal is again opened, but there it is barely five feet thick.

In Harrison county, openings are quite numerous along the railroad, and the coal is mined extensively for shipment. Notwithstanding the presence of a good deal of pyrites, it finds a ready market as a gas coal.

At Clarksburg, one of the most extensive openings shows the structure of the bed as follows :

Coal, 3 ft. 6 in.; Parting, ½ in.; *Coal*. 5 ft. 4 in.; total, 8 ft. 10 in.

Excepting four inches at the bottom, the lower bench is a fine clean

coal, while the upper bench is somewhat bony, quite hard and bears much resemblance to the ordinary roof coal of this bed as seen farther north and northwest. The parting varies from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. and is persistent in all the openings in this vicinity. In the lower bench there occur three thin partings, twelve, fifteen and eighteen inches respectively from the bottom, between which is the soft coal, the "bearing-in bench" of the miner. The character of this lower bench is precisely the same with that of the lower division of the Pittsburg throughout northern Ohio. Some pyrites occur here, but the quantity is not great. The upper bench contains a layer of "slate," four inches thick and irregular in its place. On the north side of the railroad the seam is much troubled by sandstone horsebacks, some of which are quite extensive, having been traced for more than half a mile across the entries of different openings. In one bank such a horseback was found, eight feet wide. It was followed for five hundred yards, but showed no sign of thinning out. Along the whole distance, it has not only cut out the coal, but has also trenched the fire-clay and sandstone below. It is said to be more compact than the overlying sandstone.

At Wilsonburg, four miles west from Clarksburg, the coal shows an average thickness of seven feet six inches, but near the mouth of the main entry increases to eight feet four inches. The parting is black clay, and varies from $\frac{1}{8}$ to 2 in. The coal at the base for one foot is very poor and hardly marketable, but the remainder of the lower bench is a very fine coal, containing, it is true, much nodular pyrites; but this is easily separated. There are no well-defined minor partings in this bench. The upper bench is quite hard and contains much splint coal. It is said to be quite as good for gas-making as the lower portion is, so that all parts of the bed are shipped together, the single foot at the base excepted, as that is too sulphurous.

At Coketon, the bed varies from five to seven feet. For three inches at the bottom the coal is very bad, but the whole bed above is taken out for shipment. The upper bench is heavy, compact and leaves much ash. The parting is one inch thick and consists of hard carbonaceous clay. Pyrites occur plentifully throughout the bed, but, being in nodules, is readily removed. The roof is a slickensided clay.

Where the bed disappears, near Wolfe's Summit, it is six feet thick and roofed with ten feet of argillaceous shale. East from Clarksburg, it is mined at Bridgeport and several other localities, but only to supply local demand. Numerous banks are worked in a small way along the West Fork River, and on the road to Shinnston, in this county. They show no material difference from those already described.

In Taylor county, openings were seen near Pruntytown and Flemington, in each case near the eastern outcrop of the coal. At Pruntytown, the bed is single and nearly eight feet thick. Above it is a dull reddish-gray shale, on which rests a massive sandstone. The coal, for the most part is somewhat inferior here, as the roof is very thin and usually not

sound. At Flemington the thickness is eight feet. There are no distinct partings, and the roof is a shaly sandstone, which occasionally forms a troublesome horseback. The coal from the banks here is said to be very good and to command a ready market for use in gas-making.

Lower Barren Group. It will be remembered that in the section given in my former paper, eight strata of limestone, having in all a maximum thickness of thirty feet, were represented as belonging to this group. These disappear southwardly, so that at Clarksburg only two remain, one underlying the *Pittsburg* coal, and the other about one hundred feet below it. Still farther south, in Lewis county, we find that only the upper one holds out, and that disappears long before reaching the Great Kanawha River. Even the fossiliferous limestone, which, in the Ohio Reports, I have named the *Crinoidal Limestone*, thins out finally before reaching the Northwestern Branch of the Baltimore and Ohio Railroad, though it is persistent in Ohio, Pennsylvania and northern West Virginia. The fossiliferous shales accompanying this limestone were traced to near Pruntytown, in Taylor county, beyond which, southward, they were not seen. Not far from Pruntytown, they yield beautiful specimens of *Productus prattenianus*, *Nucula ventricosa*, *Nucula* (?) *anodontoides*, *Yoldia carbonaria*, *Yoldia stevensoni*, *Edmondia aspenwalensis*, *Pleurotomaria* (?) *tumida* and *Bellerophon meekianus*.

Southward to the railroad and east from the Laurel Hill axis, the shales increase greatly, but farther toward the south and especially along the axial line they are replaced by sandstone, so that on the Staunton pike, where the whole section is fully exposed for three hundred feet below the *Pittsburg* coal, the only rocks are sandstones. East from the axis the shales predominate, and for the most part are of a deep brick-red color. The same color characterizes them in the disturbed region at the west.

In Upshur and Randolph counties, between Buckhannon and Beverly, the Lower Barren Group seems to contain no coal, but in the vicinity of the former village, there is a small seam about forty feet below the *Pittsburg*. Between Buckhannon and Clarksburg another is seen about one hundred feet below that coal, and it occurs also at the latter place.

The thickness of this group shows little variation along the eastern border, and is not far from four hundred feet.

Lower Coal Group. In Upshur and Randolph counties, it is impossible to procure a detailed section of this group without the expenditure of very much more time than was at my disposal. The whole country is deeply buried under debris, and connected exposures are rare. The rapid and somewhat irregular increase of dip near Rich Mountain, and the long stretches of "concealed," along the roads and streams render the building of a section exceedingly difficult. It is, however, sufficiently evident that this group, barely two hundred feet thick, near the Pennsylvania line, has rapidly developed so as to be in these counties

scarcely less thick than on the Great Kanawha River, where it is nearly nine hundred feet from the Conglomerate to the top of the Mahoning Sandstone. The following partial section, beginning with the Mahoning Sandstone, is said to have been obtained in a salt well bored on Buckhannon River:

1.	Rock	60 ft.
2.	*Coal*	15 ft.
3.	Shale	32 ft.
4.	Sandstone	40 ft.
5.	*Coal*	4 ft.
6.	Rock	160 ft.
7.	*Coal*	4 ft.
8.	Sandstone	40 ft.
9.	*Coal*	3 ft.
10.	Sandstone	120 ft.
	Total	478 ft.

The boring clearly stopped far short of the base as it did not reach the large and very persistent coal bed resting on the Conglomerate. As nearly as can be determined, the thickness of the whole group is not far from seven hundred feet.

No. 1 of the section, the Mahoning Sandstone, is ordinarily separated from the underlying coal by from six to ten feet of shale. It is a coarse sandstone, with numerous lines of pebbles, arranged parallel to the general plane of bedding. Some portions show extensive cross-bedding, and occasionally the rock is a coarse conglomerate. It is of uneven texture, and weathers into irregular cavities. Rude casts of vegetable stems are of common occurrence, and a thin coal is sometimes found about forty feet from the base.

No. 2 is the *Upper Freeport Coal*. Its changes in Upshur, Randolph and Barbour counties are very interesting. East from Buckhannon, on the Beverly road, it is first seen at the Sand Run crossing, in a deserted opening. The shale above it is dark, fissile, and about seven feet thick. Above this is the Mahoning Sandstone. The first satisfactory exposure is on Roaring Creek, at the foot of Rich Mountain, where the coal is worked and shows the following section:

		Ft.	*In.*
1.	Shale, drab, argillaceous	10	
2.	*Coal*		4
3.	Shale, dark, argillaceous	2	4
4.	*Coal*		10
5.	Clay, carbonaceous		1
6.	*Coal*		10
7.	Clay		¼
8.	*Coal*		9

		Ft.	In.
9.	Clay		¼
10.	*Coal*, semi-cannel	1	1
11.	Clay		½
12.	*Coal*, mostly semi-cannel	3	2
13.	Clay, slickensided		4
14.	*Coal*	1	9
15.	Shale, drab		4
16.	*Coal*, poor, seen	1	11
	Total		

Of this section, the portion from No. 4 to No. 14, inclusive, yields a coal, fairly good, but of very uneven quality. It is a good fuel, and carelessly examined, appears to be quite clean. Under a glass it shows many minute crystals of pyrites, and when exposed to the weather, soon becomes streaked with copperas, so that its commercial value is at least doubtful. On Sand Run, several miles south from the crossing of the Beverly road, a remarkable expansion of the bed is exposed in the bank of the stream. The section is as follows:

		Ft.	In.
1.	Bituminous shale	5	
2.	*Coal*		7
3.	*Cannel*, poor	2	6
4.	Shale, slightly carbonaceous	4	
5.	*Coal*, slaty	1	10
6.	Shale, slightly carbonaceous	1	3
7.	*Coal*, partly cannel	2	2
8.	Clay, drab		8
9.	*Coal*, bony		6
10.	Clay		8
11.	*Coal*, slaty	1	1
12.	Clay, with streaks of *Coal*	1	2
	Total	21 ft.	6 in.

In all this, the only coal which is fit for any purpose is No. 7, and even that is good for fuel only in case nothing else can be had. Yet this enormous mass of bituminous shale and bad coal has aroused great expectations throughout Upshur county. Its vastness, as reported on by a voluntary committee of the Legislature, is said to have caused a number of the legislators to look with favor upon Buckhannon as the site for the State Capital. The prevailing opinion respecting this bed is that its value is incalculable, whereas it is utterly worthless. Passing over to Grassy Run, another tributary to Buckhannon River, we find this bed mined on the property of Mr. G. Marple. Only a portion is exposed, giving the following section:

		Ft.	In.
1.	Arenaceous shale	4	
2.	Bony *Coal*		3
3.	Parting		½
4.	*Coal*		11
5.	Clay parting		½
6.	Bony *Coal*		6
7.	Slate		11
8.	Bony *Coal*	1	4

The coal from this bank is not very highly esteemed. About a mile farther down the run, an exposure in a bluff is as follows:

		Ft.	In.
1.	*Cannel*, very poor	4	
2.	*Coal*, bony	1	11
3.	Clay, slickensided	2	2
4.	*Coal*, semi-cannel		8
5.	Shale, carbonaceous		3
6.	Sandstone		3½
7.	*Coal*		4
8.	*Cannel*, poor	1	1
9.	*Coal*, slaty		11
10.	*Coal*, good	1	4
11.	Clay		9
12.	*Coal*, bony		4
13.	Clay		6
14.	*Coal*		5
15.	Shale, drab		8
16.	*Coal*	1	6
17.	Clay, slickensided with remains of plants and streaks of coal, seen	1	
	Total	18 ft.	1¼ in.

A similar section occurs on Buckhannon River about ten or eleven miles above the village of Buckhannon, but it is unnecessary to give it here. The coal is visible at many points along Roaring Creek to Tygart's River, and on that stream to within a few miles south from Grafton. On Roaring Creek, Mr. Jabez Woolley has measured it at three exposures, where he found the thickness eight, twelve and twenty feet respectively. Wherever it falls below twelve feet, it contains coal in sufficient bulk to be workable. The quality seems to be quite inferior throughout this region. Ex-Gov. Pierpoint informs me that some years ago it was proposed to mine this bed on Tygart's River, seven or eight miles above Grafton. The coal exhibited was very handsome, and to the naked eye showed no evidence of pyrites, but as soon as it was put under a glass it proved to be loaded with minute crystals of that mineral. It was thought

unnecessary to resort to chemical analysis for further information, and the enterprise was abandoned.

Near Weston, in Lewis county, this coal is said to occur in the bed of West Fork River, which is very probable, as the river cuts through the Laurel Hill anticlinal north from Weston. Following this anticlinal northward, we find it rapidly increasing in sharpness, so that at Valley Falls, where it is cut by Tygart's River, the Great Conglomerate is in the bed of the stream, and the Mahoning Sandstone barely crosses the crest unbroken. Near this point, at Nuzum's Mills, probably forty miles from Weston, the following section of the Lower Coal Group is obtained:*

		Ft.	*In.*
1.	Sandstone	60	
2.	*Coal*	3	
3.	Sandstone	30	
4.	Limestone	3	
5.	Sandstone	30	
6.	*Coal*, U. Freeport	5–6	
7.	Sandstone	45	
8.	*Coal*	2	
9.	Fire-clay, compact	1	
10.	Sandstone and shale	65	
11.	*Coal*		6
12.	Shale	15	
13.	*Coal*	0–3	
14.	Fire-clay, compact	3 to	6
15.	Iron ore	2 to	6
16.	Shale	15	
17.	Great Conglomerate		
	Total		

The *Upper Freeport* here shows, *Cannel*, 1 ft.; Bituminous *Coal*, 4 to 5 ft. It is somewhat inferior owing to the presence of much sulphur, but is a good strong fuel. On Prickett's Creek, in the same county (Marion), the cannel is at the bottom, and in greater quantity. Extensive arrangements were made here, years ago, for distilling oil from the coal, but the discovery of petroleum brought the enterprise to premature dissolution. On Booth's Creek, in Monongalia county, some old openings are still accessible. One a little way north from the creek shows:

Clay, 1 ft.; *Coal*, 1 ft. 11 in.; Clay, 8 in.; *Coal*, 2 ft. 9 in.; Clay, 2½ in.; *Coal*, 1 ft. 1 in.

A deserted opening near the old furnace on this stream gives:

Cannel, 1 ft.; Carbonaceous shale, 11 in.; *Coal*, slaty, 4 in.; Clay, 7 in.; *Coal*, 2 in.; Clay, 4 in.; *Coal*, seen, 4 ft.

* This section and the remaining notes on the Upper Freeport Coal were dropped by the printer in making up my previous paper on West Virginia.

The coal at the base is certainly much thicker than is stated. The old props lying in the deserted entry are somewhat more than five feet long. Another exposure near the mouth of the creek shows the bed much degraded, giving the following section:

Coal, 1 ft. 9 in.; Clay, 3 in.; *Coal*, 6 in.; Shale, 2 in.; *Coal*, 1 in.

The roof here is sandstone. Elsewhere upon the creek it is shale, which abounds in vegetable impressions. The coal from these openings is said to be very good fuel though it contains considerable proportion of sulphur. It contains much volatile combustible matter and cokes readily in heaps.

Returning to Upshur county, we find underlying the *Upper Freeport* Coal a sandstone about fifty feet thick, more or less flaggy, and apt to change into arenaceous shale. Below this is a thin tough limestone, not very pure, which seems to represent the Freeport Limestone. It was seen on the Staunton pike near Roaring Creek and on Sand Run. Between the limestone and the coal below, the sandstone is coarse and flaggy. The interval varies from twenty to thirty feet.

The next coal, No. 5, of the salt-well boring, was seen at only two localities, one on Roaring Creek, near the Staunton pike, and the other on Sand Run, near the great exposure of the *Upper Freeport*. It is a persistent bed and quite regular in thickness, varying little from four feet throughout this vicinity. The coal is irised, exceedingly rich in bituminous matter, and containing not a large amount of sulphur. It burns nicely and cokes well. No regular workings were found, and only "crop" coal could be examined. This is extremely brittle, so that, unless it improve greatly under the hill, it will hardly prove fit for shipping.

The beds, No. 7 and No. 9, of the boring have not been identified at any locality. Three miles east from Roaring Creek, and five hundred feet higher than the opening on the *Upper Freeport*, the blossom of a coal-bed occurs at the roadside. This is probably one of the lower beds, but the question cannot easily be determined, as eastward the dip increases rapidly in steepness, and the whole western slope of the mountain is so deeply buried under shingle and so thoroughly paved with fragments of sandstone and conglomerate, that connected exposures cannot be found.

East from this blossom, almost two-thirds of a mile distant along the pike, and very near the crest of the ridge, a coal-bed is worked. The mouth of the mine is three hundred feet higher that the blossom in the roadside. In the interval along the road everything is concealed except occasional exposures of sandstone. The bed near the crest is dipping northwestward at twelve degrees, so that the space between it and the coal above would be nearly five hundred feet, provided the dip does not vary. It is perhaps better to regard the interval as about four hundred feet. The coal is within a few feet of the conglomerate, but the inter-

vening rock is concealed. At the opening made by Mr. S. B. Hart, near the pike, the bed exhibits the following structure:

Shale, ——.; *Coal*, sulphurous, 4 in.; Black clay, 1 in.; *Coal*, 3 ft. 6 in.; Clay, 1 in.; *Coal*, 1 ft. 7 in.; total, 5 ft. 7 in.

The bottom coal is very inferior, being about one-half slate, and containing a notable proportion of pyrites. The bench next above it is a good fuel, though rather soft and toward the base somewhat sulphurous. It is extensively mined to supply Beverly and the adjacent country. I made as careful search for other outcrops as is possible in a wild region, covered with loose rocks and a dense forest. No other was found, unless the bed exposed at the head of Casseday's Fork of Buckhannon River be the same. This occurs near the crest of the ridge on the west slope, about ten miles south from the Staunton road. It is a large bed, and is most likely this coal. There is no doubt that this is the same with that found on the conglomerate in Marion and Monongahela counties. If it be as irregular in thickness here as in northern West Virginia and Ohio, its outcrop will be traced only with great difficulty.

Aside from the *Freeport*, itself reduced almost to nothing, no limestones were seen in this group. As in the other groups, the limestones disappear southward. They occur in Pennsylvania, but thin out rapidly after coming into West Virginia.

The Great Conglomerate.

This rock forms the crest of Rich Mountain for nearly sixteen miles, within the region examined. For the most part it is a coarse sandstone loaded with pebbles from ⅛ of an inch to 2 inches in diameter. Along the Staunton pike it shows some layers of slightly micaceous and very compact sandstone near the bottom. Here it is greatly increased in thickness. Near the northern line of the State it is barely three hundred and fifty feet thick, but in Randolph county, it is not less than six hundred. This expansion continues southwardly, as shown by the observations of Professor Fontaine, in the New River region. On Rich Mountain it contains no fossils, but in portions there are vast numbers of quartz crystals, some of them three-fourths of an inch long, and beautifully terminated at both extremities.

On the Staunton pike, along the eastern slope of the mountain, there was seen midway in the conglomerate, what appeared to be the blossom of a coal-bed. As I had observed no evidence of coal in the conglomerate northward from this locality, this exposure was studied with some care, but nothing definite could be ascertained. Six miles farther south, on the same side of the mountain, a small coal-bed occupies this place on the property of Mr. Bradley. There it is three feet thick, quite soft, but of excellent quality, and being almost free from sulphur, is highly prized by blacksmiths. Another opening has been made on the ridge near the bridle path, seven miles south from the Staunton pike, and a

third is seen near the same path, three miles farther south. These openings hardly deserve the name, as only a few sackfuls of coal have been taken from each. In all of them the coal shows the same character.

This little bed is of much interest. Here in the vicinity of the Staunton pike is the northern termination or better, perhaps, the beginning of the important group of "conglomerate" coals so fully described by Prof. Fontaine, in West Virginia, which farther southward become the main source of supply in Tennessee. In the northern portion of the State no coal occurs in the conglomerate. The local geologist, quoted by Prof. Fontaine and myself, who asserted that two beds occur in this group, is an ignorant man, who regarded the Tionesta Sandstone as part of the conglomerate, and so placed the Tionesta coals in this group.

Lower Carboniferous.

My observations in the Lower Carboniferous were made along the east slope of Rich Mountain at two or three localities between the Staunton pike and the Huttonsville bridle-path, a distance of somewhat more than ten miles north and south. The results therefore are not of much importance.

The red shales were seen on the Staunton pike. There they are in part quite arenaceous, and are almost a thinly laminated shaly sandstone. Their thickness cannot be accurately determined at that exposure, but I take it to be little more than fifty feet. They do not appear to contain any important deposit of iron ore, such as occurs near the Pennsylvania line. Six miles south from the Staunton pike, the shales are entirely wanting, and the conglomerate rests directly on the limestone. The line of contract is finely exposed at several localities but at none better than at a place nearly two-thirds of a mile north from Mr. Bradley's house, where the limestone and conglomerate are seen in contact along a bluff for about thirty feet.

The shales are of a deep red color, and the micaceous sandy layers are almost as deep red as the pressed brick on our house-fronts. As a whole, this series bears very close resemblance to the red shales of the Lower Barren Group, and might easily be mistaken for them. About fifteen miles north from the Staunton pike, at the gap made by Tygart's River on its passage through Rich Mountain, Mr. J. Woolley found these shales two hundred feet thick; their identity being certified by the conglomerate above and the limestone below. Within twenty miles south from that locality they have wholly disappeared.

The rapid thickening of the limestone is remarkable, contrasting strangely in this respect with those of the Coal Measures. Near the State line on Cheat River the limestone mass is barely one hundred feet thick, as ascertained by boring. In Randolph county, I saw a continuous exposure of nearly four hundred feet. A space of two hundred feet is concealed, and below that a calcareous shale occurs, so that the thickness is not less than seven hundred feet. In Pocahontas and Greenbrier

counties, the expansion is greater, reaching in the former to eight hundred feet. On the Staunton pike the topmost layers are exceedingly pure and very compact. They yield an excellent lime, and are the source of supply for the whole region to a distance of nearly twenty miles. Farther south the upper layers are quite impure, and are nearly calcareous shale. On the property of Mr. Bradley, a seam of *coal* occurs amid some shales in this mass, about two hundred and fifty feet below the conglomerate. It is two inches thick, quite impure and very sulphurous. It is seen in a little run below Mr. Bradley's house.

The fossils obtained from this limestone were found chiefly in the upper layers and are similar to those procured in Monongalia county. The most common are *Spirifer Leidyi*, *Athyris subquadrata*, *Productus elegans*, *Productus pileiformis*, *Hemipronites crassus*, *Allorisma sp.*, and *Straparollus planidorsatus*. These show the rock to be of the same age as the Chester group of the west. I had in my possession several fine specimens of *Lithostrotion canadense*, which were said to be from Randolph county, and I expected to find the St. Louis group well defined. No species belonging to that group fell under my observation, and I doubt whether the *Lithostrotion* came from this portion of West Virginia.

The strangest feature in the Lower Carboniferous of this region is the entire disappearance of the sandstones and shales usually found between the limestone and conglomerate. Judging from Rogers' reports, one would expect to find them, not merely persistent but greatly expanded, as compared with more northern localities. At Westernport, on the Potomac, they are six hundred and fifty feet thick, and in Pocahontas county, that adjoining Randolph on the *south*, they are twelve hundred and sixty feet. Yet in Randolph county they disappear completely. A local anticlinal must have existed here during the latter portion of the Lower Carboniferous period.

The Disturbed Region.

By this title I designate that portion of West Virginia lying between the line of the Ellenboro' fault and the Ohio River, which includes about midway between its east and west boundaries the especially broken tract known as the "oil-break."

The line of the Ellenboro' fault crosses the Staunton pike near Webb's Mills, on Hughes River. Northward it passes a little west from Harrisville and crosses the railroad about one-fourth of a mile east from Ellenboro'. Its place is entirely concealed on the Northwestern pike, though its presence there is indicated by the change in the character of the rocks. How far northward it extends I am unable to say, but if it continue in that direction, it should cross the Ohio River not far from New Martinsville. The best information within my reach leads me to suppose that it disappears long before reaching the Ohio. Southward this fault certainly disappears long before reaching the Great Kanawha River, for, according to Dr. Briggs, the *Pittsburg* coal shows a continuous outcrop

across the State through Braxton, Clay, Kanawha and Putnam counties to the Ohio River. Indeed, in every respect the disturbance from east to west in this region seems to have been greatest in the vicinity of the line followed by the railroad. Near Ellenboro' the fault is quite abrupt and is seen to good advantage in the creek's bed, about one-fourth of a mile from the station. On its eastern side the rocks of the Upper Barren Group are seen turned up and dipping at 26°, while on the west side the strata of the Lower Barren Group lie almost horizontally. The direction of the fault is about N. 10° E. Mag., and the upper rocks dip S. 80° E. Mag.

From this fault westward, the strata are almost horizontal, or have an easterly dip so slight that it cannot be determined by the barometer, until the edge of the oil-break is reached where they are abruptly turned up at a high angle. Within the "break," a narrow strip, nowhere more than two miles wide, the dip is irregular, but shows traces of anticlinal structure, and at no time exceeds 5°. On the west side the conditions seen at the east are repeated. The strata are sharply upturned and dip toward the west. The angle of dip quickly diminishes and soon becomes only ten feet per mile. About five miles east from Parkersburg, another fault occurs, quite as sharp as that at Ellenboro', with the upturned rocks dipping westward. Beyond this, the rocks are almost horizontal to the Ohio River.

On each side of the oil-break the strata belong to the Lower Barren Group, as far east the Ellenboro' fault and as far west as the fault near Parkersburg. What the rocks between this fault and the Ohio River are, can be determined only by approaching them from Ohio. Before entering into a discussion of the "break," it is well to describe these rocks as they occur east and west from it.

Lower Barren Group outside of the Oil-break. Near Ellenboro', and almost directly on the edge of the fault a boring was made several years ago in search of oil. No record has been preserved, but the enterprise proved unsuccessful. Both fresh and salt water were found, and a little oil was obtained. The rocks appeared to be much shattered. At first the drill descended nearly twenty feet each day, and farther down many crevices were struck, in which the tools would drop four or five feet instantly. Five hundred feet down, the drill stuck fast and the work was abandoned.

Along the railroad, westward from Ellenboro' to near Petroleum, the section appears to be :

1. Debris, with nodular limestone	75 ft.
2. *Coal*	1 ft.
3. Flaggy sandstone	40 ft.
4. Red shales	10 ft.
5. Sandstone	15–25 ft.
6. Red and blue shale	25 ft.
7. Sandstone	10 ft.
8. Red shales and sandstone	300 ft.

The limestone and coal both were seen near Ellenboro', as well as in the hills near a deep cut three miles farther west. This coal, I take to be the same with that whose blossom is seen in the roadside between Harrisville and Cornwallis Station, not far from the former place. The sandstones, Nos. 5 and 7, are soft, light gray, somewhat feldspathic and contain much mica. The upper is the more compact and durable. Both may be seen near Cornwallis Station, where the upper stratum is quarried extensively by the railroad company for building purposes. The lower one is apt to become flaggy. No. 8 is first seen near Cornwallis, and is the prevailing rock exposed in the cuttings from that place to near Petroleum, except near Silver Run Summit, four miles east from Petroleum, where the grade of the road brings one into the upper members of the group. The shales greatly predominate. When freshly exposed, they resemble a reddish shale enclosing nodules of sandstone. The whole, however, is a mass of slightly arenaceous clay shale, without definite bedding, of dull red color, with brownish patches, and readily breaking up into coarse powder on exposure. The color is characteristic, and once seen cannot fail to be remembered. No such shale occurs in the Upper Barren Group. It does occur in the Lower Barren Group along Buckhannon River and the Staunton pike, in Upshur county. No other group resembles it except the Red Shales of the Lower Carboniferous. Near Petroleum we find under it a sandstone, which, doubtless, belongs to the Lower Coal Group.

Along the Northwestern pike only the upper members of the group are exposed, until one approaches the eastern slope of this "break."

Southward from the railroad the rocks show the same character. At a short distance west from Harrisville a boring was made for oil. It was continued to the depth of five hundred feet and then abandoned. No record of it is accessible. I am informed that for most of the distance the drill passed through red shales, and that two very thin beds of coal or carbonaceous shale were passed through. On the Staunton pike, these rocks are well exposed for nearly twenty miles, by the road. They are said to contain two very thin beds of coal. Of one of these I saw the blossom about three miles west from Webb's Mills. It seems to be about ten inches thick. A very notable feature just east from the break is a sandstone, about twenty feet thick, resting on shale.

Leaving aside, for the present, all reference to the strata involved in the slopes of the oil-break, we pass across the break to the west, where we find a similar series of rocks, differing only in this, that the red tint is not the only one in the shale, many portions along the railroad having a bluish cast.

Upon the line of the railroad, west from Laurel Junction, we find the rate of dip quickly decreasing to less than one degree. Before reaching the tunnel, one mile west from the Junction, the blossom of a thin coal is seen in a low cut. This is probably two hundred feet higher than the rocks in the Junction cut, and is overlaid by a mass of bluish-red shale

and sandstone. From the tunnel westward to Walker's Station, the grade of the road falls, and meantime the dip becomes barely ten feet per mile. Nearly one mile east from Walker's, a thin coal is seen which may be traced through several cuts. It is eight inches thick, very slaty, and is no doubt the same with that just mentioned. Above it, in the hills is a succession of sandstones and red shales. Similar rocks occur all the way to Parkersburg. No break or fault was seen along the railroad, but in a well bored near Claysville, the strata are said to have been found much shattered. On the Northwestern pike the exposures are very incomplete; no succession can be made out, but there are evidences of at least two small breaks in continuity of the rocks.

Upon the Staunton pike, the exposures are quite as satisfactory as those along the railroad, for the road runs in the valleys cut by the Little Kanawha and Hughes' Rivers. Starting up the Little Kanawha from Parkersburg, we find at five miles from that city a well-marked break or fault, very similar to that observed at Ellenboro'. Up to this point the westward dip is almost zero; but here at once it increases to 25°. The exposure is at the roadside, in a cut. East from this break the strata are horizontal, at least no dip in any direction can be made out with the barometer. On both sides the rocks are apparently the same. Sandstones and brownish red, slightly arenaceous shales. Judging from their lithological characters alone, one would regard them as belonging to the same group. At a short distance below Newark, the road passes through a cut, in which is exposed a series of sandstones and dark-red shales, in all about one hundred and twenty-five feet thick. On top there is a handsome, light olive sandstone, which is quarried to supply material for building the locks on the river. Though soft, it is said to be quite durable.

At Greenville, where the road crosses Hughes' River, the same shaly sandstones and shales are seen in the river bluffs, and at some distance farther on, the massive sandstone appears in the hills, twenty feet thick and standing out as a cliff. Huge fragments of it have fallen off and lie strewn over the hillside, and in the river channel. It has been used here for building purposes, and serves well, as it is not very hard, dresses easily and is quite durable. This rock is seen along the road to within one mile of Freeport P. O., where the exposures become obscure, as we are approaching the western boundary of the oil-break. It is the same sandstone with that already mentioned as occurring just east from the break on this pike.

The Oil-break. This name is given to an irregular tract, from one to nearly two miles in width, having a general trend of N. 10° E. Mag., and with the strata on its sides, dipping N. 80° W. and S. 80° E. Mag. I have been able to examine it along the Staunton pike, the Northwestern Railroad, and the Northwestern pike, as well as at several points between these lines, embracing in all about fifteen miles of its length. The region of greatest disturbance is in the neighborhood of the railroad:

north and south from this line the abruptness diminishes. Its extent southward is not well determined. Col. Byrne, State Superintendent of Instruction in West Virginia, informed me that he had traced it to the Great Kanawha River, near Charleston. This seems hardly possible, for at the Great Kanawha, in that vicinity, there is no anticlinal, certainly there is no break. It is, however, by no means improbable that the remarkable horizontality of the strata there may result from the flattening out of this anticlinal in that direction, so that if the flattening occur gradually southward, the anticlinal might be traced to that river.

Northward, where the break crosses the Ohio River near Cow Run, it is said to be a gentle anticlinal, over which the upper rocks pass unbroken; and this belief is supported by Dr. Briggs' section along the Ohio.* In that section the whole mass between Wheeling and Pomeroy is referred to the Upper Coal Group, and the *Pittsburg* coal is regarded as being at no point more than two hundred and fifty feet under the river. There is certainly an error somewhere in this work, since in that portion of West Virginia, fronting on the river, a little south from Marietta, the surface rocks belong to the Lower and not the Upper Barren Group, for I have found the section along the Staunton pike to be the same on both sides of the break, and along the railroad it is practically the same. I have no records of borings made west from the break, but two on the east, one near Ellenboro' and the other near Harrisville, were driven five hundred feet and passed all the way through shales and sandstones, cutting at most only two streaks of coal. If these rocks belonged to the upper series, the *Pittsburg* coal should have been struck at about three hundred feet from the surface near Ellenboro', and at much less near Harrisville. At Wolfe's Summit, eight miles west from Clarksburg, the *Pittsburg* goes under, dipping northwestward, at the rate of somewhat more than one hundred feet per mile. From that place westward to Ellenboro', the strata of the Upper Coal and Upper Barren Groups are followed without a break, the dip continuing northwest all the way, though gradually diminishing in sharpness. At Ellenboro', the rocks change and the dip becomes slightly eastward. From this line we find only the characteristic red shales with the accompanying sandstones until we reach the oil-break where the rapidly-increasing dip brings us into the Lower Coal Group. As will be shown farther on, the rocks within and the steeply-sloping sides of the break form a continuous and uninterrupted series with those outside. If this series between the oil-break and the Ellenboro' fault belong to the Upper Barren Group, what has become of the Lower Barren and Upper Coal Group? Neither of these is found along the Staunton pike, where the whole structure is very clearly exposed. It is absolutely certain that the *Pittsburg* coal appears nowhere between the Ellenboro' fault and the one a little way east from Parkersburg, except possibly in isolated patches on tops of the very highest hills.

* Rogers' Report Geol. Virginia, for 1840.

Dr. Briggs' statement can be accounted for only by supposing that the Ellenboro' fault disappears long before reaching the Ohio, and that the oil-break itself flattens out rapidly, so as to become a low anticlinal near the river, over which the upper groups may pass unbroken. Still this does not wholly remove the difficulty. What the conditions may be above Marietta, along the river, I do not know, never having examined that region; but I do know that rocks belonging to the Lower Barren Group are found near Valley Mills, in Wood county, three miles from the river and seven miles northeast from Parkersburg. In that vicinity, I was unable to discover any rocks belonging to the upper groups.

The oil-break passes through Wirt, Ritchie and Pleasants counties. Beginning at the south, let us see the structure in the vicinity of the Staunton pike, which runs along Hughes' River. The section of the west slope is very prettily exposed on Fox's Run, about one mile north from the Staunton pike, where we find :

1.	Red shales	not measured.
2.	Shaly sandstone	20 ft.
3.	Red shales	105 ft.
4.	Shaly sandstone	30 ft.
5.	Red shales	50–60 ft.
6.	Sandstone, shaly to massive	65 ft.
7.	Chert	5–12 ft.

No. 1 is not far from one hundred feet thick, and on it rests the massive sandstone already mentioned as seen along the pike west from the "break." Nos. 4, 5, 6 and 7 are wholly involved in the abrupt side, and No. 3, partially so. The sandstones are all of a dull red color, and in the wells bored just outside of the break, the whole mass was recorded as red shale. On the east side of the break the exposure is yet more satisfactory, as the road passes along the river bank, so low down as to exhibit the flexure in the flint where the dip abruptly decreases from 35° to 3°. The sandstones and shales of the preceding section are seen in the hill above the flint, thus proving indisputably that the rocks on each side of the "break" belong to the same horizon.

There is no evidence of faulting on either side. The succession from the inner portion of the abruptly tilted strata outward to the horizontal strata is unbroken and perfectly clear.

Within the break the rocks are almost horizontal and not much broken. They describe a flattened anticlinal, for beginning inside and proceeding outwards, say on the west side we find the dip first horizontal, then 2° or 3°, then 28°, then 56°, then 3° or 5°, and finally outside almost horizontal. A similar condition is found on the eastern edge. Along the line of section the chert is the last to show the abrupt dip.

If now we ascend the hill from Fox's Run and go east about one-third of a mile we find near Mr. Sharpnack's steam-mill, the sandstone and

chert almost horizontal. The sandstone is the highest rock in the hill. The section is as follows:

1.	Sandstone	60 ft.
2.	Chert	6–12 ft.
3.	Shale and limestone	9 ft.
4.	Black shale	3 ft.
5.	*Coal*	6–12 inches.
6.	Shale and sandstone	120 ft.
7.	Sandstone to river	not measured.

The chert is light-red to yellow, and in some cases dove colored. It is quite compact, and forms a striking feature in both sides of the break as well as on the hills within it. It is well exposed on the pike, where it has been used for macadamizing the road. The limestone in No. 3, occurs in nodules, varying from two inches to two feet in diameter. It is variegated and extremely compact. If a sufficient quantity could be obtained, this would be valuable as an ornamental marble for indoor use, since it receives a beautiful polish. The *coal* is sulphurous and slaty. It can be seen on the pike near each edge of the break. The sandstone, No. 1, is said to contain a *coal*, eight inches thick. The black shale overlying the *coal* No. 5, is quite rich in fossils. In a few minutes, I obtained from it a large number of individuals belonging to the following species: *Chonetes granulifera*, *Solenomya sp.*, *Schizodus sp.*, *Pleurotomaria grayvilliensis*, *Bellerophon montfortianus*, *Bellerophon percarinatus* and *Euomphalus subrugosus*. From this shale some very fine specimens of a *Nautilus*, allied to *N. occidentalis*, have been procured.

Near Freeport P. O., midway in the break, a well was bored to the depth of fifteen hundred feet, but the record seems to be wholly lost. All accounts agree in stating that for several hundred feet before the work was stopped, the drill passed through nothing but red shale. In a boring made near the middle of the break, thin coals are said to have been met at sixty, eighty and one hundred and twenty feet, respectively, from the surface. By comparing the results of two borings made here by Mr. J. Lillie, I make out the following partial section within the break:

1.	Sandstone	60 ft.
2.	Chert	6–12 ft.
3.	Shale and limestone	9 ft.
4.	Shale	3 ft.
5.	*Coal*	6–12 in.
6.	Shale	30 ft.
7.	Sandstone	59 ft.
8.	Shale	41 ft.
9.	Sandstone	105 ft.
10.	Shale	9 ft.
11.	Sandstone	76 ft.

12.	Shale	14 ft.
13.	*Coal*	3 ft,
14.	Shale	20 ft.
15.	Sandstone	27 ft.
16.	Shale	6 ft.
17.	Shale, black	10 ft.
18.	Shale	50 ft.
19.	Sandstone	20 ft.
	Total	553 ft.

Oil was found in Nos. 9 and 19. The *coal*, No. 13, is said to be very soft and in appearance to resemble the Grahamite. It is not exposed everywhere and has been found only in borings.

Respecting the horizon of these rocks there is no room for doubt. The chert is undoubtedly the same as that found on the Great Kanawha River, immediately below the Mahoning Sandstone. Here, as so frequently elsewhere in West Virginia, that sandstone holds a thin bed of coal. The shale below the chert is rich in species of fossils, which, in the Appalachian region, are thus far utterly unknown at every horizon above the middle of the Lower Barren Group. Such a fossiliferous shale is very often found between the Mahoning Sandstone and the immediately underlying coal. From the sandstone down, the whole facies is that of the Lower Coal Group, and at an inconsiderable depth the shales of the Lower Carboniferous are reached.

Along the line of the Northwestern Railroad, the conditions are much more complicated, and one finds some difficulty in working out the true structure. Here the uplifting agency was exerted much more energetically than on any other line, whether north or south from the railroad.

Approaching Laurel Junction from the west, we pass through the Lower Barren Group. The strata are dipping westward very slightly until we approach the station, when the dip instantly changes to 30°, and within a very short distance increases to 75°. It then declines almost as rapidly to 2° or 3°. On the east side of the break near Petroleum, the conditions are similar, the easterly dip suddenly increasing from a fraction of one degree to twenty, and then to thirty-six degrees. On each side of the break the uplifted rocks are certainly not far from eight hundred feet thick, and they may possibly be somewhat more. The disturbed conditions renders it difficult to make a good estimate. In these rocks we find near Laurel Junction a thin coal bed, one foot, separated by about ten feet of shale from a slaty coal, barely eight inches thick. Both coals are badly broken, fire-clay and shale having been forced into them. From information given me by Prof. Fontaine, I am inclined to think that this same double bed is seen a little farther east in another cut, still sharply upturned. Near Petroleum, a similar bed is involved in the abruptly sloping rocks, and a little east from that village a thin coal is occasionally worked, which is said to be double and to resemble the one

under consideration. There seems to be no room for doubting that the coal near Laurel Junction and that at Petroleum are the same.

Prof. Fontaine, nearly two years ago, made a very careful section along the railroad from Laurel Junction to the middle of the break, where the summit of the anticlinal is shown. He has very kindly submitted his notes to me without restriction. In the main, the results of my observations do not differ from those previously obtained by him. I do not reproduce the section, as the details are unimportant here.

Within the break, that is, in that portion where the rocks lie somewhat irregularly horizontal, a *coal* is seen in several cuts. The section in connection with it varies slightly, owing to crushing, while the coal itself exhibits every evidence of having been subjected to strong pressure. The following sections were obtained at different points upon the railroad. No. I, being by Prof. Fontaine, and No. II, by myself:

I.		II.	
1. Massive sandstone	12′+	1. Sandstone, massive	25′
2. Black arenaceous shale	5″–4′	2. Shale	2′–4′
3. *Coal*	30″	3. *Coal*	15″–23″
4. Gray sandstone	3½′	4. Sandstone and shale	6′
5. *Coal*	8″	5. *Cannel*	10″
6. Black shale	3′	6. Clay	3″
7. Flaggy sandstone	—	7. *Coal*	8″–12″
		8. Shale to track	6′

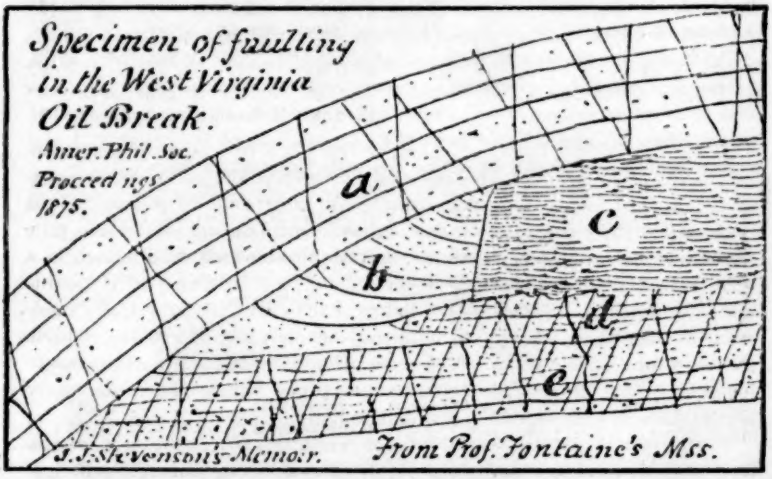
At the base of the massive sandstone there is a thin layer of conglomerate made up of rounded pebbles, one-half inch in diameter and cemented by oxide of iron. The shale contains no impression of plants. This seam is evidently the same as that mined near Volcano, about one mile north from the railroad, where the section to the coal, as obtained in a well, is shale 40′; sandstone, 40′–50′; *Coal*, 3′–5′. The *coal* is double and very irregular in thickness. Below it the rocks are principally sandstone to a depth of nearly five hundred feet, beyond which are reddish shales, which have been bored to seven hundred feet more without reaching their base. Two thin coals have been found within the break above this main bed, but they are not persistent.

Within the break the strata are thrown about in considerable confusion, and well-marked faults are not infrequent along the railroad line. One of these is exhibited in following figure, which, as well the description, I take from Prof. Fontaine's manuscript, the details being more satisfactorily given than in my own notes.

The fracturing of the rocks is especially marked on the western side of the break. The superintendent of one of the oil companies informed me that, on that side, it has never been found necessary to "torpedo" the wells, while that expedient is necessarily resorted to on the east side. The anticlinal structure is well shown west from Petroleum in the first cut which exposes the *coal*.

There is no room to doubt that the original structure here was that of an anticlinal, but certainly there is no true anticlinal now. This is easily shown by reference to only a few facts.

East and west from the break along the railroad, the rocks do not differ materially in character from those in similar position along the Staunton pike, where the relations are very clear. They are, therefore, of Lower Barren age. Borings made near the pike, say twelve miles south from the railroad, show the thickness of the Lower Coal Group and the Conglomerate to be not far from six hundred feet, and borings immediately north from the railroad show about the same thickness. In the several cuts near Laurel Junction on the railroad, there are exposed several hundred feet of strata dipping at angles varying from ten to seventy-five degrees. These cannot belong wholly to the Lower Barren Group, for by far the greater portion has no equivalent in that group, being sandstone clearly underlying the mass of shales. From what we know of the Coal Measures in this portion of the trough, it is deemed impossible for the Barren Group to increase so enormously within barely twelve miles. The greater portion of these upturned rocks must belong to the Lower Coal Group, and must be identical with the shattered fragments arranged in rude horizontality between the sides of the break.



"'*a*'—rather heavy bedded gray sandstone, weathering reddish brown; '*b*'—thin sandstone plates, placed on each other like saucers, and abutting on '*c*,' which is a bluish fine shale; '*d*' and '*e*' are dark heavy bedded sandstones"

Such being the case, it is evident that we have here the remains of an anticlinal. All the conditions go to show that the upheaval was not slow, but very violent, even explosive. It seems as though the rocks had been blown out with such force as to fracture them on the crest of the anticlinal and as though the fragments, thus produced, had fallen into the broad gulf and keyed up the sides. In conversation, Prof. Fontaine has compared the conditions with those which would result if the top of a hollow anticlinal was battered in, and the simile is a good one. What the na-

ture of the agency producing the disturbance was, it is difficult to determine. It certainly was exerted over a broad area, extending in the region examined from the line of the Ellenboro' fault to the Ohio River. Fissures are frequent throughout this area, the most notable one being that containing the Grahamite. This has been fully described by Prof. Fontaine in the American Journal of Science.

The oil is obtained chiefly from rocks, which I regard as belonging to the Great Conglomerate. The grade, for which this region is particularly noted, is of heavy specific gravity and is known as lubricating oil. Lighter oils are obtained, but occur at a greater depth than the others.

Appendix. Since writing this paper I have received from Dr. W. H. Sharp, of Volcano, West Virginia, the records of eighteen borings made in different portions of the oil break. A comparison of these leaves no room for doubt that the strata within the break, though apparently horizontal, are badly broken up, in many places even dove-tailing or not infrequently crushed into irregular masses. This is sufficiently evident from the variations in the interval between two well marked strata,—the coal-bed, already mentioned, and a limestone at some distance below. It is possible, however, to make an approximate estimate of the thickness of the rocks, for several wells bored at somewhat distant localities show a close agreement. I give condensed sections of four borings. No. I is near the eastern edge; No. II is in similar position, but one mile farther south; Nos. III and IV are near the central line of the "break" and were made on lots 56 and 33 of the Volcanic Company's tract:

I.

1. *Coal*	3′	
2. Shale	7′	387 feet.
3. Sandstone	23′	
4. Dark Shale	63′	
5. Gray Sandstone	79′	
6. Light Shale	33′	
7. Gray Sandstone	24′	
8. Shale and S. S.	81′	
9. Aren. Shale and L. S.	77′	
10. *Limestone*	22′	
11. Shale	101′	133 ft.
12. Sandstone	32′	
13. Variegated Shale	388′+	

II.

1. *Coal*	3′	
2. Interval not given in detail, but chiefly Gray Sandstone	233′	
3. *Limestone*	25′	
4. Shale and Sandstone	123′	135 ft.
5. Sandstone	12′	
6. Variegated Shale	213′+	

III.

1. *Coal* and Shale	8′	
2. Sandstone	80′	426 feet.
3. Dark Shale	32′	
4. Gray Sandstone	16′	
5. Shale	128′	
6. Sandstone	170′	
7. *Limestone*	8′	
8. Sandstone and some Shale	138′+	

IV.

1. *Coal* and Shale	11′	
2. Sandstone	17	338 feet.
3. Dark Shale	12	
4. Sandstone	58	
5. Shale	48	
6. Shale and S. S.	23	
7. Sandstone	82	
8. Sandstone and S.	56	
9. Sandstone	42	
10. *Limestone*	17	
11. Sandstone &c.	39+	

In these sections the interval varies from 233 to 426 feet. In another boring, which passes through both the coal and the limestone, the distance is 364 feet. Two other wells were driven to a depth of 386 and 397 feet respectively below the coal, without reaching the limestone. In all these wells the succession of strata is strikingly similar, though there is no resemblance in the thickness of individual layers. It seems quite probable that the interval is not far from three hundred feet, making all due allowance for exaggerated thickness owing to irregular dip of the rocks. The abrupt variations in the interval can be accounted for only by supposing that the strata are not only broken, as they usually appear in many of the railroad cuttings, but also actually crushed by lateral pressure, as indeed is shown in one of the illustrations given above. That this crushing is a common phenomenon appears from the frequent occurrence of the term "floating sand" in the records.

The record of one boring gives, as overlying the limestone, "18 feet of sandstone and *coal*." Since this coal is referred to in no other record, I am inclined to regard the statement as an error. Above the main coal and separated from it by a thin stratum of shale, there is in every instance a sandstone, whose thickness appears to vary from 20 to 80 feet. On this in two localities and eighty-five feet above the main bed is a thin coal, two feet thick, and, at one place, still another seam, of similar thickness occurs sixty-three feet higher. Above are shales for a considerable distance, probably two hundred feet. These borings confirm the conclusion, previously given, that the main coal is the Upper Freeport of Pennsylvania, the No. VI of Ohio.

Eleven of the borings pass through the limestone and five others show by their sections that they have stopped not far short of it. In fourteen of these, the overlying rock is described as sandstone and in the other two as sandy shale. In twelve instances the sandstone is more or less conglomerate. Respecting the limestone I have no direct information. It is seen in a run near the railroad, a short distance east from Laurel Junction, but no search has been made in it for fossils. Under the limestone, sandstone occurs in ten borings and black shale in one. In four instances the sandstone is quite conglomerate. Below the sandstone is the variegated shale, whose thickness is unknown. Near the Staunton pike it is more than seven hundred feet.

This succession leaves no room to doubt that the overlying rock is the Great Conglomerate, that the limestone is the Lower Carboniferous limestone (Umbral) and that the underlying rocks are the Waverly Conglomerate and shales (Vespertine).

Oil is found in the Great Conglomerate as well as in the shales and conglomerate of the Waverly. The heavy lubricating oil, for which this district has been celebrated, occurs at the upper horizon, while the lighter oils are obtained at greater depths. Dr. Sharp informs me that extensive "water-veins" are seldom encountered in the borings.

ON THE TRAPS OF THE MESOZOIC SANDSTONE IN YORK AND ADAMS COUNTIES, PENNSYLVANIA.

By Persifor Frazer, Jr., A. M.

(*Read before the American Philosophical Society, April* 16, 1875.)

Chemical Properties.

All igneous rocks consist principally of compounds of some kind of feldspar (or Nepheline or Leucite) with pyroxene, hornblende, mica or quartz, and generally with some magnetite and other subordinate minerals. All these again may be divided into those poor in Silica or Basic, or those rich in Silica or Acidic.*

The average compositions of these two kinds of igneous rocks are:

	BASIC.		ACIDIC.	
	PER CENT.	AVERAGE.	PER CENT.	AVERAGE.
Silica	45–60	52	55–80	67
Alumina	10–25	17	10–15	12
Ferrous oxide } Ferric oxide }	1–25	13	1–15	8
Lime	1–15	8	0–8	4
Magnesia	1–12	7	0–4	2
Potash	1–9	5	1–11	6
Soda	1–7	4	2–8	5
Water	0–4	2	0–6	3

Taking these ideal average percentages of the constituent compounds of these two classes of rocks, throwing them into a more convenient form and neglecting small fractions, we have:

BASIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	24.96	27.0	27
Aluminum	9.00	8.0 }	10
Iron from Fe_2O_3 say	4.5	2.0 }	
Iron from FeO say	5.0	1.5 }	10
Calcium	5.7	2.3 }	
Magnesium	4.3	2.7 }	
Potassium	4.1	0.8 }	
Sodium	2.9	1.0 }	
Hydrogen	0.2	1.8 }	
Total oxygen		47.1	

Of course it is understood that these figures represent no combination

* Rocks Classified and Described, by B. v. Cotta. Translated by H. Lawrence. London. Longmans, Green & Co., 1866.

of elements actually possible, and that the ratio of the Oxygen of the Silica to that of the protoxide and sesquioxide bases is only approximative to that of a mixture of minerals representing a mean of the highest and lowest percentages of those elements which are more commonly found in Basic igneous rocks.

The same remark applies equally to the next following class:

ACIDIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	32.16	34.84	34.84
Aluminum	6.38	5.62	6.82
Iron from Fe_2O_3 say	2.80	1.20	
Iron from FeO say	3.08	0.92	9.67
Calcium	2.86	1.14	
Magnesium	1.22	0.88	
Potassium	3.24	2.76	
Sodium	3.70	1.30	
Hydrogen	0.33	2.67	
Oxygen		51.33	

Bunsen's* classes were as follows:

	PYROXENIC.	TRACHYTIC.
Silica	48.47	76.67
Alumina Ferric oxide	30.16	14.23
Lime	11.87	1.44
Magnesia	6.89	0.28
Soda	1.96	3.20
Potash	0.65	4.18
Total	100.00	100.00

Bringing them into the same form as the above, we have:

PYROXENIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	23.26	25.21	25.21
Aluminum (say 15 p. c. Al_2O_3)	7.95	7.05	11.60
Iron (say 15.16 p. c. Fe_2O_3)	10.61	4.55	
Calcium	8.47	3.40	6.69
Magnesium	4.22	2.67	
Sodium	1.45	0.51	
Potassium	0.54	0.11	
Oxygen		43.50	
Total acid and basic radicals	56.48		

* Pogg. Ann., 1851, Vol. LXXXIII.

TRACHYTIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	36.80	39.87	39 87
Aluminum (say 7 p. c. Al_2O_3)	3.71	3.28	5.45
Iron (say 7.23 Fe_2O_3)	5.06	2.17	
Calcium	1.03	0.41	2.06
Magnesium	0.17	0.11	
Sodium	2.37	0.83	
Potassium	3.47	0.71	
Oxygen		47.38	
Total acid and basic radicals	52.61		

In the Journal of Science and Arts, Vol. IX, March, 1875, is a paper by Mr. Geo. W. Hawes, on the Trap Rocks of the Connecticut Valley, in which a number of closely accordant analyses of dolerites are given, the specimens being selected from various localities in the Mesozoic Sandstone Belt of that State.

A Dolerite taken from a dyke known as West Rock, and standing west of New Haven, gave to Mr. Hawes the following results, which have been embodied in the form of the preceding hypothetical compositions.

ANALYSIS I, OF WEST ROCK.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	24.86	26.94	27.02
Phosphorus	0.06	0.08	
Aluminum	7.55	6.65	7.72
Iron (from Fe_2O_3)	2.48	1.07	
Iron (from FeO)	6.36	1.90	8.58
Manganese (from MnO)	0.32	0.10	
Calcium	7.58	3.00	
Magnesium	4.67	2.96	
Sodium	1.59	0.56	
Potassium	0.32	0.06	
Ignition	0.63		
Oxygen		43.32	
Acid and basic radicals	56.42		

On comparing this analysis with the hypothetical composition of Cotta's Basic Igneous Rock, it will be observed that the Silicon (including under this head the small per cent. of P. present in West Rock), is almost the same in both, as also is the percentage of radicals in the protoxide bases, while the per cent. of Oxygen of both protoxide and ses-

quioxides, and the per cent. of the radicals of the sesquioxide bases are somewhat less in the actual, than in the hypothetical analysis.

In tabular form the proportions would stand as follows :

	HYPOTHETICAL BASIC IGNEOUS ROCK.	WEST ROCK.
Silicon }	24.96	24.92
Oxygen }	27.00	27.02
Aluminum } }	13.50	10.03
Iron (from peroxide) } }		
Oxygen }	10.00	7.72
Radicals of protoxide bases }	22.20	20.84
Oxygen }	10.00	8.58

A mean of 40 analyses of Labradorite recorded in Dana's Mineralogy, is as follows :

	PER CENT.
Silica	53.09
Alumina	27.96
Ferric oxide	1.33
Magnesia	0.93
Lime	10.88
Soda	4.09
Potash	1.08
Water	0.84
Total	99.39

Or in the simple form :

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	25.48	27.61	27.61
Aluminum	14.73	12.96 }	13.36
Iron (from Fe_2O_3)	0.93	0.40 }	
Magnesium	0.24	0.15 }	5.26
Calcium	7.77	3.11	
Sodium	3.03	1.06	
Potassium	0.98	0.19	
Hydrogen	0.09	0.75 }	

Mr. Hawes extracted enough crystals of pyroxene from one specimen of Connecticut trap to enable him to determine its constitution.

It bears the nearest resemblance to an Augite of the Rhone, analyzed by Klaproth :

	Si.	Al.	Fe.	Mn.	Ca.	Mg.	Ignition, Alkalies and Loss.	Total.
Connecticut pyroxene .	24.34	1.88	11.90	0.63	9.53	8.34	2.65	56.62
Oxygen.....	26.37	1.76	3.40	0.18	3.82	5.29		40.82
Augite (Rhone*).....	24.96	3.06	8.48	0.19	1.00	7.80	4.23	54.49
Oxygen.....	27.04	2.70	2.54	0.06	4.00	4.95		41.29

Assuming the pyroxene analyzed by Mr. Hawes to represent that constituting part of these traps, and assuming furthermore, the above average of 40 analysis of Labradorite as constituting the remaining part, we have the following comparative table, which is calculated by comparing the sum of the percentages of each element of the two minerals with double the percentage of the same element in West Rock.

PER CENT.

Elements.	Labradorite.	Augite.	West Rock.		
			Double Equivalent.	Deficient.	In Excess.
Si.	25.48	24.34	49.72	0.10	——
P.	——	——	0.12		0.12
Al_2^{vi}	14.78	1.88	15.10	1.51	——
Fe_2^{vi}	0.93	——	4.96	——	4.03
Fe'' & Mn''	——	12.53	13.36	——	0.83
Ca.	7.77	9.53	15.16	2.14	——
Mg.	0.24	8.34	9.34	——	0.76
Na.	3.03	1.65(?)	3.18	1.50(?)	——
K.	0.98	1.00(?)	0.64	1.34(?)	——

Of the constituents necessary to form a mixture of one molecule of each of the above mentioned minerals, there are in West Rock :

* Dana's Min., p. 218, II. 7.

CHEMICAL UNITS.

Elements.	Deficient.	In Excess.
Al_2^{vi}	0.165	—
Fe_2^{vi}	—	0.216
Fe″ & Mn″	—	0.030
Ca.	0.107	—
Mg.	—	0.063
Na.	0.065	—
K.	0.034	—
Sum.	0.371	0.309
Si.	0.014	—
P.	—	0.011

Supposing the basic radicals in excess to replace those deficient, there are wanting 0.062 (= 0.28 p. c.), and of the acid radicals 0.003 units (= 0.018 p c.) to fulfil theoretical requirements.

Or, to throw this into a rough practical form susceptible of easy comparison :

Double Equivalent of Constituents of West Rock.				
Si (P. &c.)	24.92 × 2		25.48	1 molecule Labradorite.
			24.34	1 " Augite.
	=	49.82	49.82	
Al_2^{vi} &c.	10.03 × 2		15.66	1 molecule Labradorite.
			1.88	1 " Augite.
	=	20.06	17.54	
Dyad and Monad Basic Radicals,	20.84 × 2		11.80	1 molecule Labradorite.
			30.40	1 " Augite.
	=	41.68	42.20	

A specimen of Dolerite was taken from Beeler's farm, 2 miles S. W. of York, York county, Pa., and submitted to Dr. F. A. Genth for analysis, which is as follows :

	PER CENT.			Oxygen.
Silicic acid	52.53	Silicon	24.51	28.02
Phosphoric acid	0.15	Phosphorus	0.06	28.24 | 0.10
Titanic acid	0.32	Titanium	0.19	— | 0.12
Alumina	14.35	Aluminum	7.65	8.48 | 6.70
Ferric oxide	5.93	Iron (from Fe_2O_3)	4.15	8.48 | 1.78
Ferrous oxide	5.45	Iron (from FeO)	4.23	— | 1.21
Manganous oxide	trace	Manganese	—	— | —
Magnesia	7.99	Magnesium	4.79	— | 3.20
Lime	10.27	Calcium	7.33	8.00 | 2.94
Lithia	faintest trace.	Lithium	—	— | —
Soda	1.87	Sodium	1.38	| 0.49
Potash	0.92	Potassium	0.76	— | 0.16
Copper	trace.	Copper	—	— | —
Sulphur	0.08	Sulphur	0.08	— | —
Ignition	1.23			
Total	101.04			

These constituents in chemical units give:

Silicon	3.500	3.515
Titanium	0.015	
P	—	
Aluminum	0.834	2.050
Iron (from sesquioxide)	0.222	
Iron (from protoxide)	0.150	
Magnesium	0.399	
Calcium	0.366	
Sodium	0.060	
Potassium	0.019	
Difference		1.465

DOLERITE FROM BEELER'S.

Total units in rock	11.130
Chemical units of Si. and Ti.	3.515
" " of basic radicals	2.050
Excess of units of Silicon, &c.	1.465

(*Neglecting Sulphur*)

	CHEM. UNITS.
Total chemical units of oxygen.....	5.565
Excess of units of acid over basic radicals (= units of saturating oxygen).....	1.465
Linking oxygen	4.100
= 32.80 p. c.	
Saturating Oxygen = 11.72 p. c.	

Hence the conclusion that 4.09 p. c. of this rock is Silicon combined as ortho-silicic acid, according to the formula $M'_4Si^{iv}O''_4$, and the remaining 20.51 per cent. exists in the form of the mono-meta acid, or as $M'_2Si^{iv}O''_3$.

The excess of the chemical units of Si. over those of the basic radicals, will also serve to explain the fact (mentioned to me by Mr. Hawes in reference to the Ct. Traps, but which I have not yet sufficiently verified in those from our own State), that in many cases free Silica is observed in them.

It may be added that the reduction of the analysis of these rocks to a form which gives the measure of chemical force employed in the composition of their constituent minerals, and in a single unit, *i. e.*, the ratio of the percentage weight by the equivalence to the atomic weight, seems a very convenient one to employ in discussing the questions here considered.

It is interesting to observe that while the analysis of the Connecticut Dolerite agrees very well with a mixture of one molecule of Labradorite to one of Pyroxene, that from Beeler's farm corresponds even more closely with a mixture of two molecules of Labradorite to one of Pyroxene. In this table the same analyses of Labradorite and Pyroxene are used as in the former case.

3 molecules of Beeler's dolerite.			
		49.40 (24.7 × 2)	2 molecules of Labradorite.
Si.	24.65 × 3	24.34	1 molecule, Pyroxene.
	= 73.95	73.74	
Al^{vi}_2 &c.	11.81 × 3	32.40 (16.2 × 2)	2 molecules, Labradorite.
		1.88	1 molecule, Pyroxene.
	= 35.43	34.28	
		23.60 (11.8 × 2)	2 molecules, Labradorite.
Dyad and Monad Basic Radicals,	18.45 × 3	30.40	1 molecule, Pyroxene.
	= 55.35	54.00	

OPTICAL PROPERTIES.

SYENITE (?) FROM CEMETERY HILL, NEAR GETTYSBURG, ADAMS CO., PA.

Contains Feldspar, Hornblende and Magnetite, and some Biotite, with Quartz rarely. With a single Nicol's prism, the blades of Hornblende are fully dichroic. Both that and the feldspar are speckled and spotted.

Between two Nicol's prisms the Labradorite polarizes through blue, yellow, and lilac; the Hornblende from white to brown and black; and the Quartz, which is sparingly present, gives brilliant colors.

In the thick specimen examined under the microscope the feldspar differs from that of the equally thick specimens of dolerite in being more transparent and "icy"-looking, resembling Adularia, and here and there are seen small grains of a transparent mineral giving the rainbow colors of quartz.

The fine slice reveals the feldspar in a state not easily distinguishable and of weathered appearance, and also several objects, which from their colors, green and red, resemble small fragments of pyroxene. While therefore, there is no doubt of the occurrence of hornblende in sufficient quantity to give the character to this rock, the question as to its proper name will be remanded to future study.

DOLERITE FROM BEELER'S FARM, 2 MILES S. W. OF YORK.

This slide at 275 diameters and between Nicol's prisms, shows an aggregate of irregular portions of crystals of pyroxene and Labradorite with the accompanying magnetite. The surfaces of the crystals are rough, but they do not seem to be so much affected by weathering as in that marked No. 3.

DOLERITE (No. 3) FROM BEELER'S FARM, 2 MILES S. W. OF YORK.

The Labradorite and pyroxene of this specimen, under 275 diameters, appear in much the same condition as those of the slide from the Mumper dolerite. The blades of Labradorite are twinned and sometimes geniculated; the two individuals polarizing alternately light and brown.

Certain parts of this slide are very rich in a fine rod-like crystal apparently uniaxial which may be set down with safety as apatite. A very large number of these little crystals is distributed throughout the whole mass.

DOLERITE FROM MUMPER SHAFT, 1 MILE N. OF DILLSBURG, YORK CO., PA.

The thin section (magnified 56.8 diameters) and with $\frac{1}{8}$ in. aperture, exhibits blades of Labradorite very finely and regularly striated, mixed together with yellowish green masses of pyroxene irregularly cleft and stippled on the surface like fish roe and containing magnetite, around which is to be seen a brownish-yellow stain due to its partial conversion into ferric hydrate. With appertures of $\frac{1}{2}$ in., $\frac{1}{4}$ in., and 3-16, the same appearances are manifest, but not so clearly.

With the Lieberkühn reflector the fragments of magnetite assume a partially metallic lustre.

With one Nicol's prism there is a faint appearance of dichroism in some isolated spots of some of the pyroxene crystals but in general there is no change.

Between two Nicol's prisms the pyroxene changes from green to pink (sometimes giving a transient spot of deep purple), and the irregular rifts in its mass are more plainly visible.

The Labradorite changes abruptly along the planes of twinning to light brown and pale greenish-blue from white. The striation is very apparent and polarization is usually complementary in two or three sections of the single blade.

The magnetite of course remains unchanged.

Between Nicol's prisms and magnified 275 diameters the outlines of the constituent crystals of this rock are very sharp, and the pyroxene in particular shows very brilliant shades of purple and green.

The cleavage is quite apparent, and the whole rock seems but little altered.

Dolerite from Logan's Shaft, 1 Mile N. of Dillsburg.

This slide resembles the others but is less decomposed and compounded of finer crystals than the others. It exhibits Labradorite, pyroxene and magnetite, besides acicular crystals which appear to be apatite.

Under 275 diameters the Labradorite and pyroxene have a rough appearance, as if covered with little bubbles, due perhaps, to incipient decomposition. A number of small needle-like apatite crystals are scattered through the mass.

The greater part of the Labradorite (which is twinned as usual) lacks sharpness of outline.

The photographs and zinc plates from the photo-zincograph process have been prepared by Mr. Anthony Wenderoth, of this city, to whom great credit is due for his skill in overcoming what have been hitherto considered insuperable difficulties. In the present state of photography it is impossible to make a picture from nature of the constituents of a complex rock of this kind, and at the same time to preserve the identity of each to the eye. Indeed the outlines of the separate minerals will blend more or less into each other when the colors are such as will affect the sensitized plate imperfectly. Another drawback is that yellow and red minerals photograph black, and the former being one element of the color of many pyroxenes, the black spots, which should indicate magnetite, are sometimes extended out of all reason, when the two last mentioned minerals occur together. Another evil is that the same mineral may, by reason of slightly differing thicknesses in different parts of the slide, assume totally different colors. And still another, is that part of the stippled effect is often due to the necessities of the process. Yet in spite of these disadvantages, some of which at least experience and patience will enable

us to overcome, these plates are among the most faithful representations of the facts as seen through the microscope which have yet appeared.

With suitable apparatus and after some prefatory trials, I have hopes of producing more perfect results, and of obtaining sharp level photographic outlines, which can be colored if necessary to correspond to five or six positions of the analyzer during its rotation.

[NOTE.—In connection with this paper a series of thin slices of Connecticut Traps, made by Mr. E. S. Dana, of Yale College, the Pennsylvania specimens referred to in the text, as also, photographs of maps of York County and Gettysburg, and the positive picture on glass of the slices of 136 diameter enlargement, were projected on the screen.]

EXPLANATION OF THE PLATES.

PLATE I.

FIG. 1. This photograph was among the first made with an $\frac{8}{10}$ microscopic objective. A portion of the edge of the section was included in the field in order that the portion represented might be more easily recognized and studied under the table-microscope.

The enlargement is very nearly 34 diameters. The original is a dolerite (No. 3) containing pyroxene (*a*), magnetite (*b*), plagioclase (labradorite) (*c*), and some scattered needles of apatite (*d*).

The previous description of the dolerite No. 3 from Beeler's farm applies to this specimen.

FIG. 2. The negative of this print was made in polarized light and is another portion of Fig. 1, Pl. IV.

The object is a specimen of dolerite from Beeler's farm marked No. 4. The rock is seen to be a confused mass of crystal fragments consisting of labradorite (*a*), pyroxene (*b*), and magnetite (*c*).

PLATE II.

FIG. 1. The negative of this print was taken with a $\frac{1}{5}$ microscopic objective, and the enlargement is about 136 diameters. The minerals constituting this rock, (which occurs on Cemetery Hill, Gettysburg, Adams County, Pa., and has been provisionally called Syenite,) are more or less weathered, as their rough appearance, caused by their numerous cavities, sufficiently shows.

a. Crystals of feldspar.
b. Hornblende.
c. Magnetite.

FIG. 2. This object is specimen 1 of dolerite from Beeler's farm, 2 miles S. W. of York, and is magnified 136 diameters.

a. Labradorite.
b. Pyroxene.
c. Magnetite.

The surfaces of both feldspar and pyroxene (and especially of the latter) are covered with small cavities.

Plate III.

Fig. 1. This is a dolerite from Logan's, a shaft contiguous to the Mumper shaft. Besides exhibiting the relations of the light-colored slabs of labradorite to each other, and the pyroxene which forms a matrix for them, there are two distinct apatite crystals reproduced in the print.

a. Labradorite.
b. Pyroxene.
c. Apatite.
Central black spot, Magnetite.

Fig. 2. Thin section of a dolerite from a shaft on Mumper's property about 1 mile N. of Dillsburg. The dyke of which this is a section cuts the ore bed at a short distance beneath the surface.

In this print there is a labradorite of unusual size, in which is imbedded a small mass (of pyroxene) (?) which appears black in this light. The striation of other labradorite crystals is distinctly seen, while the outlines of the magnetite crystals are unusually sharp.

a. Labradorite.
b. Pyroxene.
c. Magnetite.

Plate IV.

The figures in this plate were photographs of the same object but under different conditions of polarized light. Figs. 1 to 5 inclusive, were photographed in five different positions of the analyzer. A peculiar crystal of pyroxene which exhibits a median line differing in color from the body of the crystal was made the guide. The purpose of these experiments was to see whether means could not be discovered to discriminate between the effects of anactinic light and opacity, by the camera alone. The object was a thin section of a dolerite from Beeler's farm, 2 miles S. W. of York, marked No. 4.

Fig. 1. This pyroxene appears of a light color and with a dark core, which in turn contains an irregularly formed light-colored axis. The boundary between this crystal and the magnetite at its right hand extremity is sharply defined; and the division between this pyroxene and a neighboring fragment just below its lower edge is also evident.

Fig. 2. In this photograph polarizer and analyzer are in the same phase. The main crystal is still light-colored, but there is less definition about the middle part of its dark nucleus, a light band extending nearly across it at this place. The pyroxene lying below its lower edge, which was dark in Fig. 1, has now become light, and the line of division between the two crystals is nearly obliterated, except at one point where a small magnetite appears in relief against the light background. The angle of the analyzer was not determined.

In Fig. 3, the main crystal has become almost entirely black with a light core. The upper end now blends with the magnetite alongside of it, and the pyroxene on the lower side has become sensibly darker, but still leaves the small crystal of magnetite apparent. The angle of the analyzer was not determined.

In Fig. 4, with an angle of $\pm$ 135° from the first position, the appearance is nearly the same as in Fig. 1; and in Fig. 5 as in Fig. 3.

In Fig. 6, which was taken in the same position of the analyzer as Fig. 4, a new condition was introduced, viz.: a thin plate of selenite was interposed over the slide and between polarizer and analyzer. The effect is a general resemblance to Figs. 1, 2 and 4.

These attempts to utilize the art of micro-photography, for the delineation of the facts as seen through a microscope of moderate power, are yet crude and undoubtedly susceptible of very great improvement, and my only excuse for offering them to the Society in their present unfinished state, is the supreme importance of using every means in our power at the present time to illustrate the conditions of structure of these micro-crystalline (once crypto-crystalline, but now so no longer) igneous rocks; and the hope that the effort to enlist the pencil of the sun in these reproductions, however imperfect it may be in its beginning, may be ultimately successful.

It has not been attempted in this paper to specify *all* the constituents of these traps; to do this a further laborious study of many more slides would be necessary: but only to point out those of most frequent occurrence and of principal importance, which can be recognized in the photographic representations.

ON CREMATION AMONG THE DIGGER INDIANS.

By W. J. Hoffman, M. D.

(*Read before the American Philosophical Society, April* 16, 1875.)

In my last communication, I described, in part, the funeral ceremony of that sub-tribe of Pah-Utes inhabiting the vicinity of Spring Mountain, Nevada, and in looking over my notes made in 1871–2, I find that cremation was also practiced by the Digger Indians (Pah-Utes) living around Marysville, Cal. I would here state, that as far as I have been able to compare the language, or rather dialects, customs, beliefs, ethnology, etc., I am inclined to trace the various sub-tribes of Utes, Pah-Utes (including Diggers) and Gosh-Utes, to one common type. Their bands are scattered over an extent of country, from the northern interior portion of California, southward throughout that State to Owen's Lake, thence irregularly eastward into Utah and Colorado, making a distance between the two limits of about one thousand miles. The dialects are similar to a great extent, except where they have adopted many Spanish words, and these incorrectly pronounced.

Cremation as practised at Marysville, is very similar to the form at Spring Mountain, but to give as clear an idea as possible, I shall repeat it. When an Indian (*e. g.*, a male) becomes dangerously ill, all the remaining ones of that *rancheria* move a short distance away, leaving the sufferer to himself. The wife, or one of his relatives, supplies him daily with food and water. In case death ensues, the male friends of the defunct prepare everything for the usual ceremonies. Some, wrap the corpse into a blanket, and tie it with grass ropes to keep the body stiff and straight; while others gather pine wood, which they arrange into a pile about four feet broad and eight feet long, high enough to contain rather more than a cord, upon which the corpse is placed, with all his favorite valuables, such as bows and arrows, blankets, gun, etc. All the Indians then form a circle around the pile, fire is applied, and several men are stationed near, with long poles, to stir up the coals and burning embers, to hasten the work. When the body has been reduced to the smallest possible quantity or bulk, (ashes or crisp) the widow approaches and scraping up some of the resinous exudation of the pine, covers her face and hair with it, signifying that she will not entertain any proposals of marriage as long as any trace of the resin adheres to her person. The remains are then collected and transferred to a piece of blanket or buckskin, in which they are buried near camp. Their reason for burning all the usual trinkets, etc., of the dead, is the same as at Spring Mountain, *i. e.*, that when the Indian reached the better land (the white man's hunting-ground in the direction of the rising sun), he must be prepared to take part in the chase, as he was wont to do on this earth.

* * * * * * *

The Modocs, now so well known, also practised this custom as late as the year 1868, when it was discontinued, they having adopted the mode of burial practised by the tribes living to the north of their territory. The only differences were that the chief mourner would cover his (or her) face and hair with the blood and grease which ran from the burning body, instead of using the resin; and that the ashes were buried, usually, in a small basket made of grass or fine roots, and shaped like a small basin or bowl. The ashes were also buried near camp, from two to three feet below the surface.

In conclusion, I would say, if the name *Digger* is applied to those Pah-Utes who obtain their food to a great measure from the ground such as roots, lizards, etc., etc., why not call those tribes Diggers also who are lower in the scale of humanity, as the Seviches, who live on the Colorado Plateau, near the western terminus of the Grand Cañon. They are decidedly the most loathsome beings who live within the limits of the United States. (I shall report more accurately upon this, and adjoining bands in some future paper.) The Sho-sho-nees and their sub-tribe, the Snakes, also live on roots, herbs, lizards, toads and insects, besides the fish and fowl they are sometimes able to obtain.

* * * * * * *

Reading, April 5th, 1875.

LUNAR-MONTHLY RAIN-FALL IN THE UNITED STATES.

By Pliny Earle Chase, Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, April* 16, 1875.)

When the Meteorological Department of the Signal Service Bureau was first organized, I believed that the extent of territory embraced by the observations would soon furnish material for useful generalizations, in respect to the importance of climatic influences which many regard as either problematical, or wholly insignificant.

If any considerable improvement in our present system of weather forecasts should ever become possible, it will doubtless be brought about by a fuller understanding of cyclical changes. Howard and Sabine long ago showed that barometric pressure and magnetic force are sensibly affected by the moon, and the cumulative effect of undulations is such that the daily atmospheric tides, though singly of small magnitude, may, by regular succession, lead to such blendings of currents as will produce cyclical winds and storms. By my numerous comparative investigations I have shown that, while there is a great discrepancy in the forms of the lunar rain curves at different stations, the discrepancy is no greater than is found in the solar curves. I have also shown that there is a likeness between the curves for different independent periods, at the same station, which cannot be attributed to chance, such likeness being most striking, and the inflections of the curves being greatest where the lunar-tidal forces are strongest.

Any normal lunar, or planetary, wave-producing influence may be greatly obscured by local or accidental disturbances. The daily announcements of "probabilities" often seem to fail in a given locality, when the weather map shows that they are wonderfully verified in an entire region. So a lunar disturbance which would ordinarily bring rain, may be marked by cloud or wind at some stations, while, if we had reports from the entire district, we should find a general prevalence of rain. We may, therefore, look for results from observations at a large number of stations, extending over only a few years, analogous to those which would be shown in a long series of years, by the observations at a single station in the same district.

The influence of the Rocky Mountains upon our storms has been well known since the days of Redfield and Espy. The intersections of normal winds, near the base of those mountains, as well as the analogous intersections which occur in the West Indian birthplace of tornadoes, I have pointed out in a previous paper. In neighborhoods where there is a natural tendency towards a blending of currents, cumulative tidal influences may be supposed to have a special efficiency.

Influenced by these views, I have examined the morning weather maps for the past three years, tabulating, in accordance with the moon's age, both the number of reporting stations and the reported rain-fall upon

each map. I then divided the total rain-fall upon each day of the lunar month by the total number of stations reporting for the corresponding day, and took successive differences between the resulting averages, by Airy's method. The normals thus deduced are given in the accompanying table, together with the normals for various local curves. The curve deduced from 43 years' observations at Philadelphia, covers a longer period than any other to which I have had access in the United States, and its striking resemblance to the Signal Service curve is shown by the diagram. The resemblance is the more significant in view of the fact that the periods represented by the two curves are entirely independent. The flexures in the Philadelphia curve average about $1\frac{1}{2}$ days earlier than those of the general curve. On the hypothesis of cumulative tidal undulations, this would represent a daily difference of $1\frac{11}{45}$ hours, or $22\frac{1}{2}°$, a difference corresponding to disturbances originating in our Western territories.

Occasional breaks in my series of weather maps, the interference of storms with the transmission of reports, and other causes, combine to render these results imperfect, but their indications are of such a character as to convince me that a careful study of the full returns, which are forwarded thrice a day to the Signal Service Bureau, would lead to the discovery of important laws governing the lunar influence at various seasons of the year, at various periods of the day, and in various sections of the country.

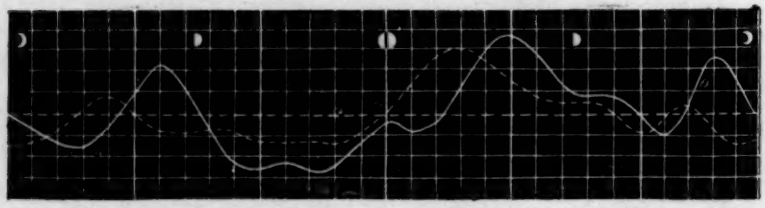
Lunar-Monthly Rain-fall, from Observations of Signal Service Bureau, and at Local Stations.

Lunar Day.	March, 1872 to Sept. 1873.	Sept. 1873 to April, 1875.	March, 1872 to April, 1875.	Philadelphia, 1835 to 1868.	San Francisco, 1849 to 1872.	Barbadoes 1847 to 1873.	Lisbon, 1854 to 1870.
1.....	105	96	100	93	97	90	106
2.....	106	88	96	94	97	79	106
3.....	101	86	94	97	94	77	99
4.....	99	87	92	102	92	84	90
5.....	98	94	96	103	96	89	85
6.....	104	104	103	100	104	88	83
7.....	111	110	111	97	107	85	84
8.....	106	108	107	96	108	82	89
9.....	97	102	97	96	107	86	93
10.....	85	94	89	96	103	93	98
11.....	93	84	87	95	97	99	105
12.....	100	79	88	94	99	106	118
13.....	95	81	87	94	110	110	128
14.....	87	87	87	94	125	107	126
15.....	87	97	93	96	138	98	118
16.....	91	103	98	100	134	93	117
17.....	87	102	96	106	115	96	126
18.....	87	105	97	113	105	103	135

Lunar-Monthly Rain-fall, from Observations of Signal Service Bureau, and at Local Stations—CONTINUED.

Lunar Day.	March, 1872 to Sept. 1873.	Sept. 1873 to April, 1875.	March, 1872 to April, 1875.	Philadelphia, 1825 to 1868.	San Francisco, 1849 to 1872.	Barbadoes 1847 to 1873.	Lisbon 1854 to 1870.
19.....	101	113	107	115	104	104	135
20.....	117	115	116	113	96	104	124
21.....	127	112	119	108	85	104	106
22.....	123	107	114	104	83	109	85
23.....	109	105	107	102	86	116	68
24.....	102	107	104	102	88	121	62
25.....	105	104	104	99	89	125	67
26.....	104	98	99	96	86	123	77
27.....	94	98	95	98	81	116	86
28.....	89	109	100	101	85	108	91
29.....	94	118	113	99	93	105	93
30.....	100	111	106	95	96	100	100

In the diagram each vertical space represents .05 of the mean rainfall; each horizontal space, a lunar day. The curves begin and end on the day of new moon. The Signal-Service curve for three years is the unbroken line; the Philadelphia curve for 43 years, the broken line.



Stated Meeting, January 1, 1875.

Present, 14 members.

Vice-President, MR. FRALEY, in the chair.

A letter accepting membership was received from Rawson W. Rawson, Esq., Governor of Barbadoes, dated Government House, Nov. 24, 1874.

Letters of acknowledgment were received from Royal In-

stitution, London, Dec. 2, 1874, (92); the Chemical Society, London, (92); the Society of Antiquaries, London, Dec. 8, 1874, (92; wanting 88); Mr. J. D. Cox, Toledo, Ohio, Dec. 24, 1874, (92); the Anthropological Institute of Great Britain and Ireland, London, 4 St. Martin's Place, W. C., Dec. 1, 1874, (92).

Letters requesting (62 and 88) missing numbers of the Proceedings were received from the Royal Geographical Society, London, 1 Saville Row, Burlington Gardens, W., Dec. 3, 1874.

A letter respecting publications for 1875 was received from Putnam & Sons, Fourth Avenue and Twenty-third street, New York, Dec. 17, 1874, for Amherst College.

A letter from A. H. Barclay, President, Rantoul Literary Society, Rantoul, Champaign County, Ill., Dec. 26, 1874, acknowledging receipt of (92) Proceedings and giving an account of the progress of that Society was read.

Donations for the Library were received from the Natural History Society at Emden, Royal Academy at Brussels, Geographical Society at Paris, Rèvue Politique, editors of London Nature, Boston Natural History Society, Worcester County Medical Association, Franklin Institute, editors of Penn Monthly, and the U. S. Department of the Interior.

Prof. Frazer exhibited a new and convenient retort for the manufacture of oxygen; a hollow cone of copper plate, fitting tightly down upon a short conical ring of copper plate, mounted upon a disc or base of the same, and forming a box to receive the residuum. Plaster of Paris is run into an outside groove to lute the joint. The instrument is cleaned with speed and ease; the resistance is so slight as to render an explosion little dangerous. Prof. Frazer claimed for it the merit only of being a convenient modification of Prof. Morton's apparatus.

Mr. Briggs described an explosion at Kirkbride's Hospital, by which the engineer of that institution was killed, although connection was made through a pipe 80 feet long.

He thought experimenters should take warning by the frequency of these accidents. Prof. Morton, after three explosions, made habitual use of a water trap.

Prof. Frazer then read a paper in defence of Prof. Tyndall, entitled "Criticism of the Belfast Address of Prof. Tyndall."

Prof. Chase communicated additional results respecting the Magnitude of Gravitating Waves. (See page 344.)

The report of the judges and clerks of the annual election was then read, by which it appeared that the following officers for the ensuing year had been elected:

For President,

George B. Wood.

For Vice-Presidents,

John C. Cresson, Isaac Lea, Frederick Fraley.

For Secretaries,

E. Otis Kendall, John L. LeConte, Pliny E. Chase, J. P. Lesley.

Councilors for three years,

Daniel R. Goodwin, Eli K. Price, W. L. W. Ruschenberger, Henry Winsor.

For Curators,

Joseph Carson, Charles M. Cresson, Hector Tyndale.

For Treasurer,

J. Sergeant Price.

J. P. Lesley was nominated as Librarian.
Pending nominations 764, 765 were read.
New nomination 766 was read.
And the meeting was adjourned.

Stated Meeting, January 15, 1875.

Present, 15 members.

Mr. Fraley, Vice-President, in the chair.

A letter resigning membership on account of his inability to attend the meetings was received from Mr. Lloyd P. Smith, of Germantown, Philadelphia.

A letter requesting Proc. No. 88 was received from the London Horticultural Society, per Prof. Asa Gray, Dec. 31, 1875.

A letter requesting Proceedings January–June, 1872, pp. 225–232, was received from the Boston Athenæum, dated Jan. 8, 1875.

A letter acknowledging Proceedings 81 to 92 and asking for the preceding numbers of the set, was received from Mr. R. S. Williamson, dated San Francisco, Jan. 2, 1875.

Letters of acknowledgment were received from the Agricultural Society at Lyons, Oct. 30, 1875, (Proc. 1 to 91, wanting 5, 17, 21, 23, 26, 29 to 31, 34, 63 and 64); and from the London Statistical Society, London, Dec. 14, 1874 (92).

A letter of Envoy was received from the Royal Society of Victoria, dated Melbourne, March 10, 1874.

Circular letters were read from the K. K. Geological Institute, Vienna, respecting its Twenty-fifth Anniversary Festival, Jan. 5, 1875; from the Royal Belgian Academy respecting a monument to M. Quetelet; from the Canadian Parliamentary Companion; from the Linnean Society at Lyons; and from the Congrès Internationale des Américanistes.

Donations for the Library were received from the Royal Society at Victoria; The German Geological Society; the Physico-Medical Society at Erlangen; the Zoölogische Garten; the Flora Batava; Agricultural Society at Lyons; Nouvelles Météorologiques, and Revue Politique at Paris; Royal Astronomical Society, Chemical Society, Victoria Institute, and Editors of Nature; the Cornwall Polytechnic Society; American Journal of Science, New Haven; New York Ly-

ceum of Natural History; Journal of Pharmacy; U. S. Survey of the Territories; Department of the Interior; and the Editors of "the Western."

Mr. Wharton called attention to the fact that there seemed to be a movement on foot to favor the inauguration of another Arctic Expedition; suggesting that the Society should take the initiative by proposing to the Secretary of the Navy a plan which should involve the use of the stores of the Polaris.

Mr. Delmar, by invitation, read a memoir on the Progress and Statistics of Spain, previous to and since 1855, the date of the Great Reform laws. (See page 301.)

On motion, Mr. Lesley was chosen Librarian, and the standing committees were nominated and elected for the ensuing year:

Finance,

Mr. Fraley, Mr. E. K. Price, Mr. Marsh.

Publication,

Dr. LeConte, Dr. Brinton, Dr. H. Allen, Dr. C. M. Cresson, Mr. Tilghman.

Hall.

Gen. Tyndale, Mr. E. Hopper, Mr. S. W. Roberts.

Library.

Dr. Coates, Mr. E. K. Price, Dr. Carson, Dr. Krauth, Mr. Whitman.

Pending nominations 764, 765, 766 were read.

Pending nominations 764, 765 were balloted for.

On motion the reading of the list of members was postponed.

On scrutiny of the ballot boxes by the Presiding Officer, the following were declared duly elected members of the Society:

Dr. Jared P. Kirtland, Ohio.

Mr. John B. Pearse of Philadelphia.

And the meeting was adjourned.

Stated Meeting, February 5, 1875.

Present, 13 members.

Vice-President, MR. FRALEY, in the chair.

A letter enclosing his carte de visite photograph for the album was received from Dr. Robert Peter, dated Lexington, Ky., Jan. 28, 1875.

A letter of acknowledgment (92) was received from the Rantoul Literary Society, Jan. 26, 1875.

A letter of envoy was received from Mr. Alex. Agassiz, dated Cambridge, Jan., 1875, stating that missing numbers of his father's works, for the Society's set, were sent by express to supply the deficiency, and requesting the return of any duplicate parts in the possession of the Society.

Donations for the Library were received from Dr. Max. Marques de Carvalho, of Rio Janeiro; Mr. F. W. C. Trafford, of Zurich; the R. Belgian Academy; the Editors of Revue Politique, and Nature, and the British Trade Journal; the Royal Astronomical Society; Mr. Alex. Agassiz, of Cambridge, Mass.; the Franklin Institute; Editors of Penn Monthly, Medical News, Journal of the Medical Sciences, Journal of Pharmacy, and the American Chemist; Mr. H. C. Carey; the Chief of Engineers of the United States; and the Geological and Agricultural Survey of Texas.

The death of Mr. Nathaniel Bradstreet Shurtleff, at Boston, Oct. 17, 1874, aged 63, was announced by the Secretary.

The death of Mr. Francis Kiernan, F.R.S., Dec. 31, 1874, was announced by the Secretary.

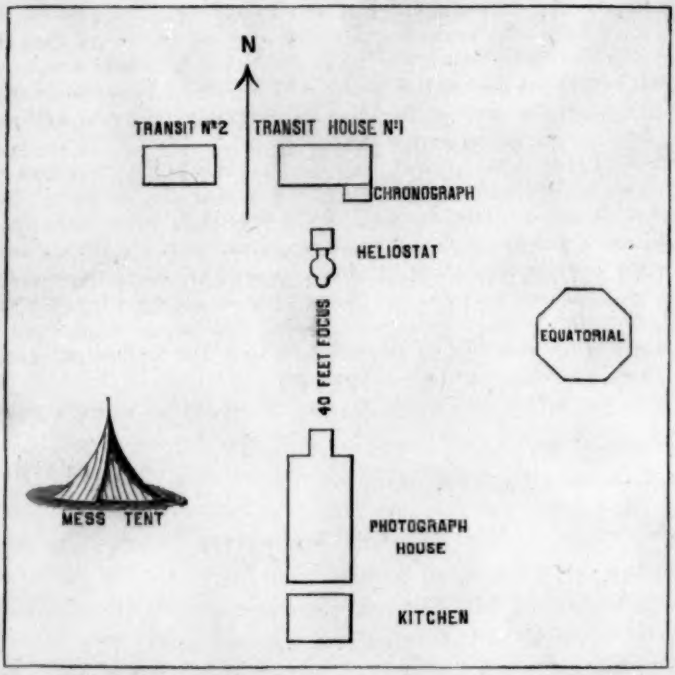
Mr. Coleman Sellers announced that he was prepared to read an obituary notice of the late Joseph Harrison at the next meeting.

A letter was received from Daniel B. Smith, of Germantown, Philadelphia, quoting a letter from Mrs. Davidson, dated Nagasaki, Dec. 10, 1874, describing the scene of observations at the time of transit:

TO THE AMERICAN PHILOSOPHICAL SOCIETY:

I have this morning received a letter from Prof. Davidson's wife, dated Nagasaki, Dec. 10, 1874, which I transcribe for the Society:

"We were 24 days on the passage over and remained one week in Yokahama and Yedo, before taking the steamer for Nagasaki. No time was to be lost, and at 12 o'clock, on the day of our arrival they had 30 coolies building the road up to the side of the observatory, which is 300 feet high, and about a mile and a half south of the town. They have been working night and day ever since, feeling somewhat hurried. You can imagine with what anxiety every cloud was watched for several days before—which had been hazy or cloudy in the mornings—blowing over by midday.



The preceding night was clear and beautiful until day-break, when clouds began rapidly to form, breaking away again about 7½, and clouding over again by 9½. The observers remained all night on the hill and the others were at their post by 7½ o'clock. I went up in a sedan chair (carried by four Coolies), and we were all at our posts of duty by ten o'clock and as the time draws nearer, you can imagine our suspense. In my husband's observatory (the large equatorial), just before the computed time, the sun seemed to be breaking through the clouds and all was in readiness; George, the largest boy holding the chronometers up to his father's eye and ear; and I seated (where I would see my husband's face,) with book and pencil in hand, with closed doors and perfect silence, save the regular

beats of the clock and chronometers. It was almost a solemn moment. The sun broke forth with one gleam—I was almost startled to my feet with the shout of "*Commence*," given by my husband, as warning to the Photographers as the instant was about to arrive. In a few seconds he gave an exclamation of delight and the first contact was accomplished and duly recorded. After giving us an instantaneous peep, observations were kept up till the next critical moment of the second contact; the sun growing less bright, but still bright enough for observations, the second contact was seen and further observations as the body was passing over the sun—growing thicker and thicker and leaving scarcely a hope for the third contact and also for the fourth which were not visible and then the whole thing was over, not wholly successful, but by no means unsuccessful, and I think my husband is pretty well satisfied; he certainly feels that they made the most of the situation, everything working well and only failed on account of the weather.

One thing strikes me as very wonderful—of course the exact spot on the sun's limb where the contact should appear was only known by computation from our previous data, and under such large magnifying power, which took in only about 5½ diameters of Venus, one minute of an arc would have been fatal. Mr. D. had gone over his calculations several times and that same morning had gone over them to satisfy himself, and then pointed his instrument and sure enough there came Venus, right in the centre of his pointing, 3½ minutes later than the English computed time, and 1½ earlier than the American time.

I hope the Society will think this account worthy of an early publication.

Respectfully,

DANIEL B. SMITH.

Germantown, 1st mo., 29th, 1875.

The letter of Mrs. Davidson was ordered to be published as soon as possible.

The Secretary presented a communication, entitled "Notes on the Geology of West Virginia," No. II., by Jno. J. Stevenson, Prof. of Geology, University of N. Y., and explained the author's work in that region, in connection with the proposed occupation of a new district in Southwestern Pennsylvania by the Geological Survey of Pennsylvania. (See page 370.)

Mr. Fraley reported the receipts, and payment to the Treasurer, of $152.79, being the last quarterly payment of the interest on the Michaux Legacy.

The following report of the Trustees of the Building Fund of the A. P. S. was read by its Treasurer, Mr. Marsh

"U. S. 5-20 Bond..	$1,000 00
"Schuylkill Nav. Co. Boat and C. loan.....	500 00
"Pennsylvania State 6 per cent. bonds.....	1,500 00
"Philadelphia City " "	6,900 00
"Stock of the McKean and Elk Land and Improvement Co., 200 shares, subscribed.....	1,000 00
"Cash	3 91
Total.....	$10,903 91

Signed—"by order of the Trustees.

BENJAMIN V. MARSH, Treasurer."

PHILADELPHIA, FEB. 5, 1875.

In the absence of members of the Hall Committee, Mr. Fraley stated, that the city authorities had undertaken to make alterations in the lower stories of the Hall of the Society, in view of another court room; and that the Insurance Companies had been consulted on the subject, and had given permission to make alterations and repairs. At his request the Secretary read from the minutes of July 17, and Aug. 21, 1863, the resolutions passed by the Society respecting the lease of said stories by the city.

Mr. J. S. Price expressed his conviction that danger to the Society's Cabinet and Library from fire was imminent; the Secretary adding his testimony to that effect.

On motion, it was then unanimously

Resolved, That the subject of the city tenancy of the two lower stories of the Hall of the Society and the proper protection of the property, from fire, or other casualty, be referred to the Hall Committee, the Presiding Officer, Mr. Fraley, and the Treasurer, Mr. Price, with power to take such order as they may think proper in the premises.

And the meeting was adjourned.

Stated Meeting, February 19, 1875.

Present, 18 members.

Vice-President, MR. FRALEY, in the chair.

Letters of acknowledgment were received from the Imperial Academy at Vienna, (90, 91), Herr Tunner, Leoben, (90, 91), Dr. Rokitansky, Vienna (90, 91), Geological Society

at Dresden (90, 91), the Society at Freiburg i. Br. (90, 91), the Society at Emden (90, 91), the Society at Geneva (89, 90, 91, XV. i.), the Society at Berne (89), and the Society at Newcastle-on-Tyne (92).

Letters of envoy were received from the Natural History Societies at Freiburg, Emden, Marburg, Berne, and Geneva.

A circular letter was received from the Linnéan Society, of Normandy, concerning a proposed statue to Elie de Beaumont at Caen.

A circular letter was received from Mr. W. Whittaker, dated Geological Survey Office, Jermyn Street, London, Jan. 30, 1875, on the part of a proposed new Geological Magazine, entitled Geology, Mineralogy, and Palæontology, British and Foreign.

Donations for the Library were received from the Prag Observatory; Vienna Geological Institute; Royal Prussian Academy; German Geological Society; Dresden Geological Society; Natural History Societies at Freiburg, Emden, Marburg, Schaffhausen, and Geneva; the Anthropological and Geographical Societies; Editors of the Annales des Mines and Révue Politique, at Paris; the Meteorological Committee of the Royal Society, and Nature, London; Prof. J. D. Dana; Silliman's Journal; American Chemist; Franklin Institute; Mr. John McArthur; McCalla & Stavely; Medical News and Library; American Pharmaceutical Association; the Geological Survey of Pennsylvania; Department of the Interior, U. S.; and Mr. A. R. Roessler.

An obituary notice of Joseph Harrison, Jr., was read by Mr. Coleman Sellers. (See page 347.)

An obituary notice of Charles B. Trego, was read by Mr. Sol. W. Roberts. (See page 356.)

The minutes of the last meeting of the Board of Officers and Members in Council were read.

Pending nominations, Nos. 766, 767, 768, and new nominations, Nos. 769, 770, 771, 772, 773, 774, and 775, were read.

Mr. Roberts reported the improvements made and to be made in the furniture of the Hall.

Mr. Fraley reported progress in negotiating a more satisfactory understanding with the city authorities, respecting the tenancy of the lower stories of the Hall building.

On motion, the Secretaries were authorized to place the new Geological Magazine, London, on the list of correspondents to receive the proceedings, if they thought proper to do so.

On motion of Mr. Price, the Committee on the Hall were authorized to obtain a new table, to re-cover the president's desk, and see to a better condition of the carpeting and furnishing of the room in which the members meet.

And the Society was adjourned.

Stated Meeting, March 5, 1875.

Present, 10 members.

Mr. Eli K Price, in the chair.

A letter accepting membership was received from Mr. J. P. Kirtland dated Cleveland, Ohio, Feb. 22, 1875.

A letter of acknowledgment (93) was received from the U. S. Naval Observatory, dated March, 1875.

A letter of acknowledgment (93) was received from the Rantoul Literary Society, Rantoul, Ill., Feb. 27.

A letter from Mr. S. P. Langley, Directory of the Allegheny Observatory, requesting the donation of Transactions of the A. P. S. was referred to the Publication Committee.

Donations for the Library were received from the Royal Academy at Brussels; Editors of the Révue Politique; Royal Astronomical Society; and London Nature; Essex Institute; Editors of Penn Monthly; Pharmaceutical Association; Medical News and Library; and Judge Brewster, of Philadelphia; Engineer Department and Secretary of War, Washington; Wisconsin Historical Society; Wisconsin Academy of Sciences and Arts; and Editors of the Western.

The death of Sir Charles Lyell was announced by the Secretary, at London, Feb. 24, 1875, aged 78 years

The death of Dr. Geo. W. Norris, at Philadelphia, March 4, 1875, aged 67 years, was announced by Mr. J. S. Price.

Mr. Cope read a paper by the title, "A Synopsis of the Vertebrata of the Miocene of Cumberland County, New Jersey." (See page 361.)

Dr. Cresson exhibited a map or diagram arranged on a vertical scale to represent the five coal beds mined at Ellengowan, near Mahanoy City, representing the thickness and subdivisions of each bed; and on a horizontal scale to exhibit the proportions of the various chemical elements obtained by analysis. Of the mammoth bed, the uppermost group of four benches is, at Ellengowan, separated from the middle group of three benches by 150 yards of rock, and the middle from the lower group of four benches by an equal distance, all three groups lying together, without the intervention of rock measures, in the neighboring collieries on each side; the total thickness of coal remaining always about the same.

Dr. Cresson exhibited and explained an American modification of Bunsen's apparatus for determining the specific gravity of any gas, and the obstacles to accuracy of the investigation when the given gas was either much heavier or much lighter than the common air into which it escaped.

Prof. Chase, being referred to, said that he had been requested by Dr. Cresson to experiment with the instrument in order to discuss its eccentricities, and had used the city gas, obtaining various curves of velocity of exit, when the uppermost and lowermost, or the two, or three, or other numbers of inches at the top or bottom of the tube were paired against each other; but without entirely satisfactory results.

He considered it probable that the causes of irregularity fell under three heads, viz.: 1st, the difference of density of the medium into which the fine jet of gas issued (through a microscopic hole in platinum foil); 2d, the vertical spiral forms into which the currents must be thrown; and 3d, friction, varying with condensation inside the instrument,

whenever the general temperature of the laboratory falls. To this latter cause he ascribed differences of results obtained in the morning and evening, amounting to twenty per cent. He thought that under favorable circumstances and with requisite care, an approximation to accuracy can be made within two per cent., and much closer than with the Bunsen instrument.

Professor Frazer communicated the fact of the discovery of titanic iron, in the form of a perfect crystal and of unusual size, half an inch on a side, associated with chlorite, in chromic iron, at Frank Wood's Mine, in Lancaster County, Pa. The specimen is in the possession of Mr. Tyson, near King of Prussia, Chester County, Pa. A small portion of the crystal was submitted to the blowpipe by Prof. Brush. (The specimen is mentioned in Dr. F. A. Genth's Report on the Mineralogy of Pennsylvania, Reports of Progress of the Second Geological Survey, 1874.)

Prof. Chase read a letter from Gov. Rawson, of Barbadoes, in which he writes that he expects to obtain the appointment, by Government, of a salaried officer, intrusted with the duty of continuing the meteorological observations at Barbadoes, the importance of which is made the greater by the fact that the island is near the hypothetical cradle of the Atlantic cyclones and tornadoes of the Gulf of Mexico.

Prof. Frazer described some microscopic sections of trap dykes on the Mesozoic red sandstone of Pennsylvania and Connecticut. He had taken specimens from the vicinity of Gettysburg, both as slides and fragments, to New Haven, and compared them with similar slides and fragments of the Connecticut traps in the possession of Mr. E. S. Dana. There were fine grained greenish dolerites exactly alike in both localities. Coarse-grained gray rock, which in fragments seemed identical, under the microscope showed differences between the Connecticut and Pennsylvania varieties; that of the former being merely a coarse-grained dolerite, while that of the latter was a true syenite. He said:—

During a recent trip to New Haven, I had the pleasure of examining the

very large collection of microscopic slides of the traps of the Mesozoic sandstone in the vicinity of that town.

Mr. Dana exhibited to me fragments of the traps, which when compared with the fragments which I had brought with me seemed to be identical lithologically so far as the eye, aided by a magnifying glass, could determine. There were two varieties of this trap which had been considered in my work essentially distinct, viz.: the doleritic and the syenitic. Both these varieties are represented within a small area in the immediate environs of Gettysburg, and even bear the appearance of running together (to judge from a rough guess from the topography). Now the finer-grained dolerite is of green color, and the specimens from New England, and those I took with me, showed under the microscope, and with the polarizer alone, the following mineral constituents. Pyroxene (Augit), plagioclastic feldspar, magnitite (in fine grains and irregular masses), and chrysolite. Mr. Hawes, of the Mineralogical laboratory, assures me that he has frequently found quartz in these dolerites.

The coarse-grained rock (both the specimen from Gettysburg and that from Connecticut,) is gray and granular, consisting of black and white crystals so mingled as to produce the familiar granite color to the eye. In fact the rock from Gettysburg is called "Gettysburg Granite." It was absolutely impossible to distinguish the fragments of this rock from the localities apart, yet under the microscope and the single Nicol the effect was very different. The Connecticut variety showed the same constituents as the other traps—was in fact a coarse dolerite; whereas that from Gettysburg showed the characteristic dichroism of hornblende, and also under a high magnifying power crystals of biotite.

In the specimen which I took with me to New Haven, there were no cleavage planes to absolutely settle the character of the supposed hornblende, but in others in my possession this was very marked and settles definitely the question of the occurrence of syenite in the Mesozoic sandstone.

Mr. Dana warns me of a possible error in this conclusion, viz.: that the mass from which I took my slides was only a bowlder—not in place. This would be a very serious objection were it not for the absolute identity of the rock in the immense masses of slab formed rock, from the quarry which supplies the tombstones and the walls of our national cemetery, as well as cubic roods of rock in Culp's Hill, Great Round Top, Granite Spur, and Devil's Den—localities which must ever remain familiar to us as connected with the history of one of the decisive battles of the world.

Besides this, as the Gettysburg locality lies miles south of the extreme southern limit of the drift, there would seem to be no adequate theory to account for such transportation.

In order to set at rest this doubt and decide this question finally, further sections will be made from rock without doubt *in situ* and the results communicated to the Society.

Pending nominations, Nos. 766 to 776, and new nominations, Nos. 777, 778 were read.

On motion of Prof. Frazer, it was

Resolved, That the Hall Committee be requested to consider the propriety of placing in the Society's rooms one of the instruments of the American District Telegraph Company, and the Treasurer be authorized to pay $18.00 as the annual rental of the same.

And the Society was adjourned.

Stated Meeting, March 19, 1875.

Present, 13 members.

Vice-President, Mr. Fraley, in the chair.

Photographs of Prof. Sadtler and Prof. Thomson, of the University of Pennsylvania, were presented for insertion in the album.

Letters of acknowledgment were received from the Literary and Philosophical Society of Liverpool, dated Jan. 25 (XIV., XV., i., 90, 91, 92); and Smithsonian Institution (90, 92).

A letter was received from the New Jersey Historical Society, Newark, March 12, requesting that deficiencies in their set of Proceedings and Transactions A. P. S. be supplied (Proc. I., II., III, 77. Transactions, all but the First Series III., i. Cat. I).

A letter was read from Mr. Wm. Holden, Librarian of the Ohio State Library, desiring to exchange copies of the Geological State Survey for Dr. Wood's and Mr. Cope's memoirs on the Arachnidæ and Myriopoda, in the Transactions and Proceedings of the American Philosophical Society.

Letters of envoy were received from the Austrian Academy, Sep. 30, 1874; the St. Petersburg Physical Central Observatory, Jan., 1875; the Greenwich Observatory, Feb. 19, 1875; the Literary and Philosophic Society, of Liverpool, Jan. 28,

1875; and Department of the Interior, Washington, March 10, 1875.

Donations for the Library were received from the Austrian Academy of Sciences; Belgian Academy of Sciences Editors of the Révue Politique; London Chemical Society; Royal Institution; Editors of Nature; Society of Arts and Institutions in Union; the (Travancore Observatory) Maharaja, of Travecore; Silliman's Journal; Prof. O. C. Marsh; and the Department of the Interior, U. S.

The decease of Nathaniel B. Browne, of Philadelphia, March 13, aged 55 years, was announced by Mr. E. K. Price, and on motion Mr. Robert Patterson was appointed to prepare an obituary notice of the deceased.

Mr. Frazer described and discussed the origin of certain beds and belts of limonite in Southern Pennsylvania, with the help of a colored map of York and Adams County, and a geological map of Pennsylvania. Dr. König and Mr. Lesley spoke on the same subject. (See page 364.)

Pending nominations 766 to 779 were read.

On motion of Dr. Cresson, for the Publication Committee, an additional appropriation of one hundred dollars was made to defray the expense of the illustrations of Dr. Allen's Memoir now being printed in the Transactions.

General Tyndale presented the request of the Directors of the Franklin Insurance Company that the Society permit Mr. Waugh to make for them a copy of the portrait of Franklin in the possession of the Society. On motion of Mr. Chase, the curators were authorized to permit such copy to be made, taking the usual and proper precautions for the security and safe return in good order of the picture.

On motion of Dr. Cresson another album volume similar to the one now filled with portraits of the members of the Society was ordered to be purchased.

And the meeting was adjourned.

NOTE BY DR. CARSON.

The picture of Franklin in the possession of the American Philosophical Society is by Martin, of London, a copy by himself of a picture painted

by him, of Dr. Franklin, for William Alexander's grandson, Henry J. Williams, Esq., of Philadelphia. The copy was placed by Franklin, about 1765, in the keeping of the Supreme Executive Council of Pennsylvania, and upon the abolition of that body at the time of the Revolution came into the hands (probably) of Mr. Peale when his Museum was in the Hall of the American Philosophical Society, and was by him there left at the removal of the Museum to the State House. This statement is made to Dr. Carson by Mr. Williams, who has the original.

Stated Meeting, April 2, 1875.

Present 15 members.

Mr. Eli K. Price, in the chair.

Letters of envoy were received from the Meteorological Office of the Royal Society, London, March, 1875; and the U. S. Department of the Interior, Washington, March 19, 1875.

A letter from Harvard College Library was received requesting a missing signature, pages 225–232 of the Proceedings, Vol. XIII.

Donations for the Library were received from the Prussian and Belgian Academies; the Editors of the Révue Politique and Nouvelles Meteorologiques; the Astronomical Society; Meteorological Committee of the Royal Society; the Cobden Club; and the Editors of "Nature;" the Chief Geologist of Canada; Essex Institute; College of Pharmacy; Academy of Natural Sciences; and Mr. Delmar, of Philadelphia; the U. S. Department of the Interior; and U. S. Department of Engineers; and the Academy of Sciences at St. Louis.

The death of Dr. D. Francis Condie, March 21, 1875 aged 9, was announced by Dr. Bridges.

Pending nominations Nos. 766 to 779, and new nomination 780 were read.

And the meeting was adjourned.

Stated Meeting, April 16, 1875.

Present 16 members.

Dr. Carson in the chair.

Letters of acknowledgment were received from the Natural History Society at Wiesbaden, the British Association, and the American Ethnological Society in New York.

A letter of envoy was received from the Central Physical Observatory at St. Petersburg.

A letter was received from the Academy of Sciences of Chicago requesting the replacement of Proceedings of the American Philosophical Society lost by the fire. On motion, the request was granted.

A letter was received from the Department of the Interior, U. S. Bureau of Education, dated March 31, calling for information respecting the Library. On motion, referred to the Librarian.

Donations for the Library were announced from the Academies at Berlin and Bruxelles; the Societies at Görlitz, Wiesbaden, and Bonn; the Editors of the Annales des Mines, Révue Politique, and Nouvelles Meteorologiques; the Royal Institution; Editors of Nature; and Mr. Robert Twining; the Société Litèraire et Philosophique, Quebec; the Massachusetts State Board of Health; Silliman's Journal; State Geologist of New Jersey; American Journal of the Medical Sciences; Department of the Interior, U. S.; and editors of the Western.

The death of Dr. Andrew A. Henderson, at the U. S. Naval Laboratory, Brooklyn, N. Y., on the 5th inst, aged 59, was announced by Mr. Lesley. On motion, Mr. Lesley was requested to prepare an obituary notice of the deceased.

The death of Mr. John Henry Towne, of Philadelphia, at Paris on the 6th inst., was announced by Mr. Lesley. On motion Mr. Sol. W. Roberts was requested to prepare an obituary notice of the deceased.

Dr. LeConte read another communication from Dr. W.

J. Hoffman, dated Reading, April 5, 1875, respecting the Practice of Cremation among the Pàh-Utes, or Digger Indians, of California. (See page 414.)

Prof. Frazer read a communication on the composition of trap rocks and gave illustrations on a screen, from slices, with a lime light, and various powers of lens. (See page 402 and plates 1, 2, 3, 4.)

Mr. Chase communicated a comparison between the lunar-monthly rain-fall in the United States as indicated by the morning weather-maps for three years, and the Pennsylvania Hospital observations for 43 years. (See page 416.)

Mr. Lesley said that the members present might be interested in the fact that he had succeeded in obtaining a cross-section projection of the two azoic mountain ranges which once occupied Southeastern Pennsylvania, giving for the first time a correct explanation of the structural geology of the gneiss and mica-slate belt commencing at Easton, on the Delaware River, and passing through Philadelphia, Delaware, Chester, and Lancaster Counties toward Baltimore. The sharp synclinal at the soapstone quarries separates an anticlinal mass to the north from a broader anticlinal mass to the south. The axis of the latter passes through the Fairmount reservoir, in Philadelphia; and a careful collation and projection of the dips observed, (by Messrs. Young and Fagen, aids on the survey,) along the Reading Railroad track, up the west bank of the Schuylkill, upon a base line of vertical section transverse to the general strike, namely, N. 5° E,—S. 5° W. shows that the highest rock now seen in that synclinal originally rode over Fairmount at an altitude of about 15,000 feet; and over the northern anticlinal at an altitude of 10,000 feet. The dips of the northern anticlinal swing round from south by east to north in a regular curve, showing that the northern mountain mass declined rapidly eastward, that is towards Easton, where the whole of the azoic sinks beneath the New Red, of New Jersey. This mountain, dying down eastward, stopped the normal course of the Schuylkill from Reading to Chester; and the present

notable zigzag of the river towards the Northeast and then towards the Southeast is thus explained. The ancient drainage passed around the eroded east end of the mountain. For a good many years he had maintained the existence of these ancient Alpine ranges in early times, but without until now deducing the opinion from regularly compiled structural elements of observation.

Pending nominations Nos. 766 to 780 were read, and Nos. 766 to 779 balloted for, and the following persons declared duly elected members of the Society:

Mr. Wm. A. Ingham, of Philadelphia.
M. Viollet le Duc, of France.
Mr. John McArthur, Jr., of Philadelphia.
Judge Joseph Allison, of Philadelphia.
Mr. Edward Penington, of Philadelphia.
Dr. Henry Chapman, of Philadelphia.
Mr. Alexander Agassiz, of Cambridge, Mass.
Prof. Frederick Prime, Jr., of Easton, Pa.
Prof. S. P. Langley, of Allegheny City, Pa.
Mr. H. S. Hagert, of Philadelphia.
Prof. C. F. Chandler, of New York.
Mr. Rossiter W. Raymond, of New York.
Prof. Leonard G. Frank, of Philadelphia.
Mr. Wm. P. Tatham, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, May 7, 1875.

Present, 20 members.

Vice-President, Mr. Fraley, in the Chair.

Letters accepting membership were received from Mr. Alex. Agassiz, dated Cambridge, Mass, April 20; Judge Joseph Allison, dated Philadelphia, April 21; Mr. John McArthur, Jr., dated Philadelphia, April 20; Prof. Leo. Geo. Frank, dated Philadelphia, April 19; Mr. H. S. Hagert,

dated Philadelphia, May 3; Mr. W. A. Ingham, dated Philadelphia, April 19; Prof. S. P. Langley, dated Allegheny, Pa., April 19; Prof. Frederick Prime, Jr., dated Lafayette College, Easton, April 19, and Prof. Rossiter W. Raymond, dated New York, April 24.

A letter of acknowledgment was received from the Royal Society, dated Edinburgh, Dec., 1874 (XIV. i. iii. Proc. 83–87).

A letter of envoy was received from the London Meteorological Office of the Royal Society dated April, 1875.

Donations for the Library were received from the Royal Academies at Berlin and Turin; the Observatories at Greenwich, Cape Town, and Oxford; the Geographical Society and Editors of Révue Politique at Paris; the Royal Geographical and Royal Astronomical Societies and Editors of "Nature" at London; and Literary and Philosophical Society, Liverpool; Natural History Society, of Northumberland, at Newcastle-on-Tyne; Royal Society and Royal Botanical Garden at Edinburgh; Royal Geological Society at Dublin; Essex Institute; Museum of Comparative Zoology, at Cambridge, Massachusetts; Boston Society of Natural History; American Antiquarian Society at Worcester; Silliman's Journal; Prof. J. D. Dana; Editors of the American Chemist; Columbia College School of Mines; New Jersey Historical Society; Editors of the Medical News and Penn Monthly; College of Pharmacy; Dr. C. M. Cresson; Mr. Lorin Blodget; the U. S. Coast Survey; U. S. Engineer Department; and U. S. Department of the Interior.

Dr. Barker exhibited the performance of his new arrangement of the galvanometer for lecture illustration, describing the successive contributions to its perfection made by Saxton, Poggendorf, Sir Wm. Thompson, President Morton, and Prof. Mayer.

A discussion followed on the galvanic currents in rocks, and the magnetism of the earth.

Mr. Blodget referred to a former communication to the Society on the subject of the vertical descent of air in the

case of the meteoric "Northers," and to similar views expressed by Professor Loomis at the last meeting of the National Academy at Washington, regretting that he had not had leisure to place all the facts which he had observed and gathered in support of his views before the Society.

Pending nomination No. 780 was read.

Mr. Fraley reported the receipt of the quarterly interest of the Michaux legacy, due April 1st, amounting, with the premium on gold, to $154.48.

And the meeting was adjourned.

Stated Meeting, May 21, 1875.

Present, 15 members.

Vice-President, Mr. Fraley, in the Chair.

A letter acknowledging the receipt of Proceedings 92 was received from the New Bedford Free Public Library.

Letters of envoy were received from the Asiatic Society of Japan, dated Yokohama, April 5; the United States Coast Survey office; the Norwegian University, Christiana; and Mr. H. Wheatland, Salem, Massachusetts, May 5, 1875.

Donations for the Library were received from the University of Norway; Dr. Boekh; the Royal Society at Göttingen; Royal Academy at Berlin; Horticultural Society, Berlin; Dorpat Observatory; Imperial Geological Institute, Vienna; Société Vaudoise, Lausanne; Editors of Révue Politique, Paris, and "Nature," London; Mr. H. Wheatland, Salem; Peabody Museum, Cambridge, Massachusetts; New Bedford Free Public Library; Prof. Dana, New Haven; Buffalo Society of Natural History; Editor of the American Chemist, New York; Department of the Interior, U. S.; and Mr. Winchell.

Letters requesting back numbers to complete a set were received from the Royal Academy, Berlin, and Trübner & Co.

Mr. Lesley described the changes made in the theoretical

geology of the country south of Lake Erie, suggested by the work of the New Geological Survey of Pennsylvania; the most important of these changes, namely, the adoption of an east and west strike for a northeast and southwest strike, being necessitated by the probability that most of the exposures of conglomerate throughout Warren, Venango, and Crawford Counties in Pennsylvania, and Cattaraugus and Chautauque Counties in New York, belong to a horizon 200 feet below that of the Great Conglomerate, No. XII, the base of the Productive Coal Measures.

Dr. Cresson referred to the discussion of thermo-electric currents at the last meeting to state his own opinion that it is not needful to have two metals, or an unhomogeneous mass of one metal for the exhibition of such currents. He had found water alone to be a sufficient medium for the production and exhibition of the phenomena under discussion.

The minutes of the last meeting of the Board of Officers and Members in Council were read.

Pending nomination, No. 780, and new nominations, No. 781 and 782 were read.

And the meeting was adjourned.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. I.

A NEW VERTICAL-LANTERN GALVANOMETER.

By George F. Barker, M.D., Professor of Physics.

(*Read before the American Philosophical Society, May 7th*, 1875.)

Desiring to show to a large audience some delicate experiments in magneto-electric induction, in a recent lecture upon the Gramme machine, a new form of demonstration galvanometer was devised for the purpose, which has answered the object so well that it seems desirable to make some permanent record of its construction.

Various plans have already been proposed for making visible to an audience the oscillations of a galvanometer needle; but they all seem to have certain inherent objections which have prevented them from coming into general use. Perhaps the most common of these devices is that first

used by Gauss in 1827, and adopted subsequently by Poggendorff and by Weber, which consists in attaching a mirror to the needle. By this means, a beam of light may be reflected to the zero point of a distant scale, and any deflection of the needle made clearly evident. The advantages of this method are :—1st, the motion of the needle may be indefinitely magnified by increasing the distance of the scale, and this without impairing the delicacy of the instrument; and 2d, the angular deflection of the needle is doubled by the reflection. These unquestioned advantages have led to the adoption of this method of reading in the most excellent galvanometers of Sir William Thomson. While therefore, for purposes of research, this method seems to leave very little to be desired, yet for purposes of lecture demonstration it has never come into very great favor; perhaps because the adjustments are somewhat tedious to make, and because, when made, the motion to the right or left of a spot of light upon a screen fails of its full significance to an average audience.

Another plan is that used by Mr. Tyndall in the lectures which he gave in this country. In principle, it is identical with that employed in the megascope; *i. e.*, a graduated circle over which the needle moves is strongly illuminated with the electric light, and then by means of a lens a magnified image of both circle and needle is formed on the screen. The insufficient illumination given in this way, and the somewhat awkward arrangement of the apparatus required, have prevented its general adoption.

A much more satisfactory arrangement was described by Professor Mayer in 1872,* in which he appears to have made use, for the first time, of the excellent so-called vertical lantern in galvanometry. Upon the horizontal plane face of the condensing lens of this vertical lantern, Mayer places a delicately balanced magnetic needle, and on each side of the lens, separated by a distance equal to its diameter, is a flat spiral of square copper wire, the axis of these spirals passing through the point of suspension of the needle. A graduated circle is drawn or photographed on the glass beneath the needle, and the image of this, together with that of the needle itself, is projected on the screen, enlarged to any desirable extent. The defect of this apparatus, so excellent in many respects, seems to have been its want of delicacy; for in the same paper the use of a flat narrow coil, wound lengthwise about the needle, is recommended as better for thermal currents. Moreover, a year later, in 1873,† Mayer described another galvanometer improvement, entirely different in its character. In this latter instrument, the ordinary astatic galvanometer of Melloni was made use of, an inverted scale being drawn on the inside of the shade, in front of which traversed an index in the form of a small acute rhomb, attached to a balanced arm transverse to the axis of suspension of the needle, and moving with it. The scale and index were placed in front of the condensing lenses of an ordinary lantern, and their

*American Journal of Science, III, iii, 414, June 1872.

†American Journal of Science, III, v, 270, April, 1873.

images were projected on the screen in the usual way by use of the objective. This instrument is essentially the same in principle as the mirror galvanometer; but it cannot be as sensitive as the latter, while it is open to the same objection which we have brought against this—the objection of unintelligibility. In the hands of so skillful an experimenter as Mayer, it seems, however, to have worked admirably.

It was a tacit conviction that none of the forms of apparatus now described would satisfactorily answer all the requirements of the lecture above referred to, that led to the devising of the galvanometer now to be described, which was constructed in February of the present year. Like the first galvanometer of Mayer, the vertical lantern, as improved by Morton,* forms the basis of the apparatus. This vertical lantern, as constructed by George Wale & Co., at the Stevens Institute of Technology, as an attachment to the ordinary lantern, is shown in the annexed cut, figure 1. Parallel rays of light, from the lantern in front of which it is placed, are received upon the mirror, which is inclined 45° to the horizon, and are thrown directly upward, upon the horizontal plano-convex lens just above. These rays, converged by the lens, enter the object glass, and are thrown on the screen by the smaller inclined mirror placed above it. The upper face of the lens forms thus a horizontal table, upon which water-tanks, etc., may be placed, and many beautiful experiments shown. To adapt this vertical lantern to the purposes of a galvanometer, a graduated circle, photographed on glass, is placed upon the horizontal condensing lens. Above this, a magnetic needle, of the shape of a very acute rhomb, is suspended by a filament of silk, which passes up through a loop formed in a wire, stretched close beneath the object glass, and thence down to the side pillar which supports this objective, where it is fastened by a bit of wax, to facilitate adjustment. The needle itself is fixed to an aluminum wire, which passes down through openings drilled in the scale glass, the horizontal lens, and the inclined mirror, and which carries a second needle near its lower end.† Surrounding this lower

FIG. 1.

*Jour. Frank. Inst., III, lxi, 300, May, 1871; Am. J. Sci., III, ii, 71, 153, July, Aug., 1871; Quar. J. Sci., Oct., 1871. In Duboscq's vertical attachment, which was advertised in his catalogue in 1870, the arrangement is similar, except that the beam received upon the mirror is a diverging one, and consequently the horizontal lens is of shorter focus. A total reflection prism, placed above the object glass, throws the light to the screen. The instrument gives a uniformly illuminated but not very bright field.

† After the new galvanometer was completed and had been in use for several weeks, I observed, in re-reading Mayer's first paper, a note stating that the idea had occurred to him of using an astatic combination consisting of two needles, one above the lens and the other below the inclined mirror—the two being connected by a stiff wire passing through holes in the condenser and the mirror. The plan of placing the coil round the lower needle does not seem to have suggested itself to him. Indeed, it does not appear that the arrangement he mentions was ever carried into practical effect.

needle is a circular coil of wire, having a cylindrical hollow core of an inch in diameter, in which the needle swings, and a smaller opening transverse to this, through which the suspension wire passes. In the apparatus already constructed (in which the upper needle is five centimeters long,) the coil is composed of 100 feet of No. 14 copper wire, and has a resistance of 0 235 ohm The accompanying cross section (Fig. 2,) of the vertical-lantern galvanometer as at present arranged, drawn on a scale of $\frac{1}{12}$, will serve to make the above description more clear. A is the needle, suspended directly above the scale-glass D, by a silk filament, passing through the loop B, close under the objective C. This needle is attached to the aluminum wire *a b*, which passes directly through the scale-glass D, the condensing lens E, and the inclined mirror F at H, and carries, near its lower end, the second needle I. This needle is shorter, (its length is 2.2 centimeters,) and heavier than the upper one, and moves in the core of the circular coil J, whose ends connect with the screw-cups at K. This coil rests on the base of the lantern, enclosed in a suitable frame. It is obvious that when the instrument is so placed that the coil is in the plane of the magnetic meridian, any current passing through this coil will act on the lower needle, and, since both needles are attached to the same wire, both will be simultaneously and equally deflected. Upon the screen is seen only the graduated circle and the upper needle; all the other parts of the apparatus are either out of the field or out of focus. Moreover, the hole in the lens is covered by the middle portion of the needle, and hence is not visible. The size of the image is, of course, determined by the distance of the galvanometer from the screen; in class experiments, a circle 8 feet in diameter is sufficient; though in the lecture above referred to, the circle was 16 feet across, and the needle was fourteen feet long, the field being brilliant.

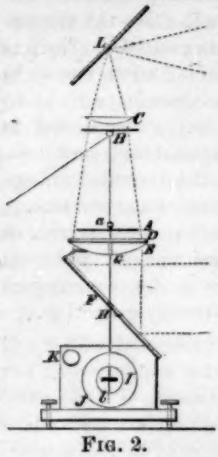


FIG. 2.

The method of construction which has now been described, is evidently capable of producing a galvanometer for demonstration, whose delicacy may be determined at will, depending only on the kind of work to be done with it. In the first place, the needles may be made more or less perfectly astatic, and so freed more or less completely from the action of the earth's magnetism, and consequently more or less sensitive. Moreover, an astatic system seems to be preferable to one in which damping magnets are used, since it is freer from influence by local causes; though, if desirable for a coarser class of experiments, the considerable distance which separates the needles in this instrument, allows the use of a damping magnet with either of them. In the galvanometer now in use, the upper needle is the stronger, and gives sufficient directive tendency to the system to bring the deflected needle back to zero quite promptly. In the experiments referred to below, the system made 25 oscillations per minute.

Secondly, the space beneath the mirror is sufficiently large to permit the use of a coil of any needed size. Since, therefore, the lower needle is entirely enclosed within the coil, the field of force within which it moves, may be made sensibly equal at all angles of deflection, as in the galvanometers of Sir Wm. Thomson. Hence the indications of the instrument may be made quantitative, at least within certain limits. The circular coil, too, has decided advantages over the flat coil, since the mass of wire being nearer to the needle, produces a more intense field. Were it desirable, a double coil, containing an astatic combination could be placed below the mirror, the upper needle, in that case, serving only as an index. The instrument above described has a coil three inches in diameter and one inch thick; the diameter of the core being one inch. Since its resistance is only about a quarter of an ohm it is intended for use with circuits of small resistance, such as thermo-currents and the like.

The results of a few experiments made with this new vertical-lantern galvanometer will illustrate the working of the instrument, and will demonstrate its delicacy. The apparatus used was not constructed especially for the purpose, but was a part of the University collection.

Induction Currents.—1. The galvanometer was connected with a coil of covered copper wire, No. 11 of the American wire gauge, about ten centimeters long and six in diameter, having a resistance of 0.323 ohm. A small bar magnet, 5 centimeters long and weighing six and a-half grams, gave, when introduced into the coil, a deflection of 40°. On withdrawing the magnet the needle moved 40° in the opposite direction.

2. A small coil, 20 centimeters long and 3.5 in diameter, made of No. 16 wire and having a resistance of 0.371 ohm, through which the current of a Grenet battery, exposing 4 square inches of zinc surface, was passing, was introduced into the centre of a large wire coil, whose resistance was 0.295 ohm, connected with the galvanometer. The deflection produced was 20°. The same deflection was observed on making and breaking contact with the battery, the smaller coil remaining within the larger.

3. A coil of No. 14 copper wire, sixty centimeters in diameter, and containing about 40 turns, the resistance of which was 0.85 ohm, was connected with the galvanometer, and placed on the floor. Raising the south side six inches, caused a deflection of 4°. Placing the coil with its plane vertical, a movement of two centimeters to the right or left, caused a deflection of 3°, and of twenty centimeters, of 10°. A rotation of 90° gave a deflection of 12° and one of 180°, of 24°. These deflections were of course due to currents generated by the earth's magnetism.

4. *Thermo-currents.*—Two pieces of No. 22 wire fifteen centimeters long, were taken, the one of copper, the other of iron wire, and united at one end by silver solder. On connecting the other ends to the galvanometer, the heat of the hand caused a deflection of the needle of 20°.

5. A thermo-pile of 25 pairs, each of bismuth and antimony, was connected to the instrument. The heat from the hand placed at five centimeters distance caused a deflection of 3°.

6. Two cubes of boiling water acted differentially on the pile. At the distance of five centimeters, the deflection was 20°: moving one to ten centimeters, the deflection was reduced to 5°.

7. *Voltaic current.*—A drop of water was placed on a zinc plate. While one of the connecting copper wires touched the zinc, the other was made to touch the water. The deflection was 16°.

The claim which is here made for the instrument however, is rather for the general principle of its construction, than for the advantages possessed by the individual galvanometer above described which was constructed at short notice, to meet an emergency. The comparatively small cost for which it may be fitted to the vertical lantern, the readiness with which it may be brought into use, the brilliantly illuminated circle of light which it gives upon the screen, with its graduated circle and needle, the great range of delicacy which may be given to the instrument by varying the coil and needles, so that all experimental requirements may be answered, and finally, the satisfactory character of its performance as a demonstration galvanometer, all combine to justify the record which is here made of it.

Philadelphia, April, 1875.

ERRATA.

The following are the Errata in "List of North American Platypterices &c.," by A. R. Grote, Proceedings No. 93, page 256:

Page 263, line 1: Mr. Lintner states that *Orepera* is the female of Robiniæ.

Page 263, line 21: for "(1793)" read "(1775)."

Page 263, line 30: for "quadrig*a*ttatus" read "quadrig*u*ttatus."